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ABSTRACT

This airframe repairman course comprises the self-study portion of an on-the-job training program. It deals with the job-related knowledge requirements for airframe repairs that are required to progress from the 3 to 5 skill level of the career field. It contains five volumes. Volume 1 (27 hours) covers the general subjects related to the operation of an airframe repair shop. Subjects such as career progression, security, publications, supply, supervision and training, maintenance management, and safety are covered. Volume 2 (54 hours) discusses the fundamentals of metal working. Volume 3 (27 hours) covers the basic repair procedures. Volume 4 (27 hours) advances the discussion into the various fastening methods, and volume 5 (42 hours) deals with the specialized repairs related to airframe repair. Subject matter is developed by a series of learning objectives which set learning goals. The text that follows each objective gives the information needed to reach that goal. Exercises following the information give a check on achievement. Answer keys appear in the back of each volume. Supplementary material provided for each volume contains replacement pages. Volume review exercises are also provided for each volume. (YLB)

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ED265362

AIRFRAME REPAIR SPECIALIST

(AFSC 53153)

Extension Course Institute

Air University

U.S. DEPARTMENT OF EDUCATION
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53153	AIRFRAME REPAIR SPECIALIST (AFSC 42755)	31 Jan 84

INSTRUCTIONS The following materials are needed to complete this course. Check this list immediately upon receiving your course package, and if any materials are missing or incorrect (numbers don't match) notify ECI immediately. Use the ECI Form 17 for this purpose, and be sure to include your identification number, address, course and volume number, and VRE form designation (if a VRE is involved). Send all correspondence separately from your answer sheet.

ITEM	TYPE	DESIGNATION OR TITLE	INVENTORY CONTROL NUMBER	VRE ANSWER SHEET IDENTIFICATION
1	ENV	ECI RETURN ENVELOPES (6 EACH)		
2		YOUR KEY TO A SUCCESSFUL GOURSE	M-140	
3	VOL	VOL 1, Basic Concepts and Principles Associated With Airframe Repair Operations	53153 01 7612	
4	VRE	VOLUME REVIEW EXERCISE (VOL 1)	53153 01 22	53153 01 22
5	VOL	VOL 2, Fundamentals of Metalworking	53153 02 7704	
6	VRE	VOLUME REVIEW EXERCISE (VOL 2)	53153 02 21	53153 02 21
7	VOL	VOL 3, Repair Procedures	53153 03 7701	
8	SUPP	SUPPLEMENTARY MATERIAL (VOL 3)	53153 03 S01 7904	
9	VRE	VOLUME REVIEW EXERCISE (VOL 3)	53153 03 21	53153 03 21
10	VOL	VOL 4, Fastening Methods	53153 04 7612	
11	SUPP	SUPPLEMENTARY MATERIAL (VOL 4)	53153 04 S01 7904	
12	VRE	VOLUME REVIEW EXERCISE (VOL 4)	53153 04 21	53153 04 21
13	VOL	VOL 5, Specialized Repairs	53153 05 7702	
14	SUPP	SUPPLEMENTARY MATERIAL (VOL 5)	53153 05 S01 7904	
15	VRE	VOLUME REVIEW EXERCISE (VOL 5)	53153 05 21	53153 05 21
16	SUPP	SUPPLEMENTARY MATERIAL (VOLs 1 & 2)	53153 00 S01 7904	
17		ECI SURVEY	99-01	99-01
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LIST OF CHANGES

COURSE NO.	CAREER FIELDS, POLICIES, PROCEDURES AND EQUIPMENT CHANGE. ALSO ERRORS OCCASIONALLY GET INTO PRINT. THE FOLLOWING ITEMS UPDATE AND CORRECT YOUR COURSE MATERIALS. PLEASE MAKE THE INDICATED CHANGES.
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NOTE: YOU ARE NOT REQUIRED TO POST ANY CHANGES LISTED ON THIS SHIPPING LIST WHICH CORRECT TYPOGRAPHICAL ERRORS, UNLESS SUCH ERRORS CHANGE OR OTHERWISE AFFECT THE MEANING OF THE MATERIAL.

1. CHANGE FOR THE SUPPLEMENT: 53153 00 S01 7904

Supplement page 58, replacement page 132, col 2, answer 087e-2: Change "Part I" to "Part III." Change "Block 1 - 15 Apr 1974" to "Block 2 - 15 Apr 1974."

2. CHANGES FOR THE SUPPLEMENT: 53153 05 S01 7904

a. Cover page, line 5: Change "47255" to "42755."

b. Page 2, pen-and-ink changes for Cover: Delete changes. Changes for Page 1R: Delete changes.

c. Supplement page 37, replacement page 124a, col 2, line 16 from bottom: Change "X" to "÷."

d. Supplement page 44, replacement page 170, answer 870-4: Change "Two soft copper blocks" to "To hold the cable between during testing."

3. CHANGES FOR THE TEXT: VOLUME 1

a. Page 77, col 1, line 20: Change "cause" to "nature."

b. Page 93, col 1, line 4: Change "ist" to "list."

4. CHANGES FOR THE TEXT: VOLUME 2

a. Page 47, col 2, line 4 from bottom: Change "found" to "formed."

b. Page 74, col 2, line 6: Change "60°" to "90°."

c. Page 173, col 1, line 5 from bottom: Change "12" to "1/2."

d. Page 188, answer 239-4: Change ""Top blade" to "Aviation snips." Answer 239-5: Change "Filing and grinding" to "Straight snips."

e. Page 190, answer 257-5: Delete.

5. CHANGES FOR THE TEXT: VOLUME 3

a. Page 27, col 1, line 18: Change "Drilling" to "Riveting."

b. Page 53, col 1, line 26: Change "filter" to "filler."

c. Page 113, col 1, line 25 from bottom: Change "1/3" to "1/2."

LIST OF CHANGES

COURSE NO.	CAREER FIELDS, POLICIES, PROCEDURES AND EQUIPMENT CHANGE. ALSO ERRORS OCCASIONALLY GET INTO PRINT. THE FOLLOWING ITEMS UPDATE AND CORRECT YOUR COURSE MATERIALS. PLEASE MAKE THE INDICATED CHANGES.
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6. CHANGES FOR THE TEXT: VOLUME 4

a. Page 12, col 2, line 7 from bottom: Change "hold" to "hole." Line 2 from bottom: Change "hold" to "hole."

b. Page 15, col 1, line 25: Delete "rejection."

c. Page 26, col 2, lines 1-4 from bottom: Delete "*Blind type lockbolts . . .* side of the."

d. Page 27, col 1, lines 1-4: Delete "work is accessible . . . fig. 2-6)."

e. Page 45, Figure 2-18, Legend: Change "inspection" to "injection."

f. Page 46, col 1, line 18 from bottom: Change "100" to "110."

g. Page 51, col 2, line 8 from bottom: Change "fugure" to "figure."

h. Page 52, Exercises (620)-2, line 1: Change "Wht" to "What."

i. Page 58, col 1, line 2: Change "for" to "by."

j. Page 63, col 2, line 22: Change "assemble" to "assembly."

k. Page 64, col 1, line 24 from bottom: Change "assemble" to "assembly."

l. Page 102, col 2, line 5: Change "amoung" to "among."

m. Page 107, Exercises (646)-10: Change "504" to "506."

7. CHANGES FOR THE TEXT: VOLUME 5

a. Cover page, line 4: Change "53153" to "42755."

b. Page 1, col 2, line 8 from bottom: After "attack by chemicals." add "Thermosetting plastics retain their shape until they become useless from deterioration, damage, etc."

8. CHANGES FOR THE VOLUME REVIEW EXERCISE: VOLUME 1

a. Page 2, question 3: In the stem of the question, change "53173" to "42755." Question 7: In the stem of the question, change "metalworking" to "fabrication."

b. Page 14, question 83: Change "(087c)" to "(087e)."

c. The following questions are no longer scored and need not be answered: 93 and 97.

LIST OF CHANGES

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9. CHANGES FOR THE VOLUME REVIEW EXERCISE: VOLUME 2

a. Page 3, question 15, choices a, b, c, and d: Delete the commas.

b. Page 5, question 29: In the stem of the question, change the second "cracks" to "parts."

c. Page 7, question 48: In the stem of the question, change "Thw" to "The." Question 52: In the stem of the question, change "tendendy" to "tendency."

d. Page 11, question 87: In the stem of the question, after "needed" add "on a 90° bend."

e. Page 15, question 124: Change "(277)" to "(278)."

f. The following questions are no longer scored and need not be answered: 26, 27, 34, 50, 60, 67, 68, 93, 95, 98, 100 and 113.

10. CHANGES FOR THE VOLUME REVIEW EXERCISE: VOLUME 3

a. Page 13, question 97: In the stem of the question, change "6" to "4."

b. The following questions are no longer scored and need not be answered: 8, 9, 21 and 91.

11. CHANGES FOR THE VOLUME REVIEW EXERCISE: VOLUME 4

a. Page 5, question 33, choice d: After "inch", add "oversize."

b. Page 6, question 35: In the stem of the question, change "Inspector" to "Inspection."

c. Page 9, question 57: In the stem of the question, change "port" to "part." Question 62, choice d: Delete "flush head."

d. Page 10, question 66: In the stem of the question, change "security" to "securing." Question 69, choice b: Change "counterbed" to "counterbore." Choice d: Change "stud" to "cup."

e. Page 13, question 91: In the stem of the question, change "which of the following plated finishes should be selected" to "what type of plated finish should the aircraft nuts have?."

f. The following questions are no longer scored and need not be answered: 36, 80 and 89.

LIST OF CHANGES

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12. CHANGES FOR THE VOLUME REVIEW EXERCISE: VOLUME 5

a. Page 4, question 24, choice b: Change "fowm" to "foam."

b. Page 8, question 53: In the stem of the question, insert "panels" between "honeycomb" and "are."

c. Page 9, question 57, choice b: Change "checked" to "held."

d. Page 14, question 99: Change "(875)" to "(876)."

e. Page 16, question 113: In the stem of the question, delete "wheel."

f. The following questions are no longer scored and need not be answered: 16, 55, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123 and 124.

NOTE: Change the currency date on all volumes to "May 1983."

53153 01 7612

CDC 53153

AIRFRAME REPAIR SPECIALIST

(AFSC 53153)

Volume 1

Basic Concepts and Principles Associated With Airframe Repair Operations

Extension Course Institute

Air University

PREPARED BY
CHANUTE TECHNICAL TRAINING CENTER
USAF SCHOOL OF APPLIED AEROSPACE SCIENCES (ATC)
CHANUTE AIR FORCE BASE, ILLINOIS

EXTENSION COURSE INSTITUTE, GUNTER AIR FORCE STATION, ALABAMA

THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND
IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

THIS CDC will help you qualify in the Airframe Repair Specialist Specialty. As a self-study portion of your on-the-job training program, it deals with the job-related knowledge requirements for Airframe Repairs that you need to progress from the 3 to 5 skill level of your career field.

In addition to completing this CDC and the course examination satisfactorily, you must satisfy the on-the-job proficiency requirements of your unit OJT program before you advance in skill level. Do not expect this CDC to be an 'Aladdin's genie" that will grant your every wish. Your on-the-job performance is equally important in your advancement.

CDC 53153 contains 5 volumes. This volume, Volume 1, covers the general subjects related to the operation of an airframe repair shop. Subjects such as career progression, security, publications, supply, supervision and training, maintenance management, and safety are covered. Volume 2 discusses the fundamentals of metalworking. Volume 3 covers the basic repair procedures. Volume 4 advances the discussion into the various fastening methods, and Volume 5 deals with the specialized repairs related to airframe repair.

In this volume, you will find the singular pronoun (he, his, him) used in its generic sense, not its masculine sense. The noun to which it refers is "person," not "man."

The codes appearing on some of the illustrations are for preparing agency identification only.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTOC, Chanute AFB IL 61868. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 27 hours (9 points).

Material in this volume is technically accurate, adequate, and current as of August 1976.

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NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

The Airframe Repair Shop

WELCOME TO YOUR FUTURE and to advancement in the Metalworking Career Field. You are taking your first step toward becoming an airframe repair specialist. We will discuss two areas in this chapter: (1) career ladder progression and (2) communications security. You are required to know both of these for advancement.

1-1. Career Ladder Progression

A very important factor in your advancement is knowing where you're going. A knowledge of your own career field provides a firm foundation for you to plan your future in the Air Force. In the following objective segments we will discuss identification of the subdivisons of the Metalworking Career Field, specialty codes, skill levels, and the duties required at each skill level.

001. Identify the specialties within the Metalworking Career Field.

The Metalworking Career Field consists of specialties that in one way or another are concerned with metals. Presently six specialties make up the Metalworking Career Field: Airframe Repair, Metals Processing, Machinist, Corrosion Control, Nondestructive Inspection, and Sheet Metalworking. Figure 1-1 illustrates an overall view of the related specialties.

Let's look at the work done by each specialty and see what type of services they can provide you as an airframe repairman.

Machinist (AFSC 531X0). The machinist manufactures and reworks machined parts. He does this through the use of various machines used for sawing, turning, drilling, reaming, and cutting threads and gears, and he planes flat and angular surfaces. He can extract broken studs, screws, and pins.

The Metals Processing Specialist (AFSC 531X1). This man welds, forges, and solders metals in fabricating and repairing metal parts. He heat-treats steel, aluminum, magnesium, and titanium alloys.

The Corrosion Control Specialist (AFSC 531X4). This specialist uses chemical and mechanical checks and special devices to identify metals and types of corrosion. He removes corrosion and treats metals with chemicals to protect them from oxidation. He applies primers and surface coats by paint spray equipment and brushes.

Nondestructive Inspection Specialist (AFSC 531X5). This man uses various electronic devices to detect hidden defects that could cause failure of metal structures. These devices are used to find internal and external cracks, voids, hard spots, and other defects in metal structures without destroying or damaging the material.

The Sheet Metal Specialist (AFSC 531X2). He constructs, installs, and repairs heat and ventilation ducts, sheet metal roofs, gutters, and downspouts. He is usually assigned to the civil engineering group since his duties do not apply to the maintenance of aircraft.

Even though all of the specialties of the Metalworking Career Field are closely related, you can see, from the brief discussion of each specialty, that a specialist in one specialty often needs help from another for special work situations.

Exercise (001):

1. In the space provided in front of each specialist title in column A place the corresponding letter in column B that identifies the specialty duty.

Column A	*Column B*
_____ 1. Machinist.	a. Applies chemicals to protect metals.
_____ 2. Metal Processing.	b. Repairs heat and ventilation ducts.
_____ 3. Sheet Metalworking.	c. Locates voids and hard spots in metal.
_____ 4. Corrosion Control.	d. Heat-treats different types of metals.
_____ 5. Nondestructive Inspection.	e. Removes broken studs, screws, and pins.

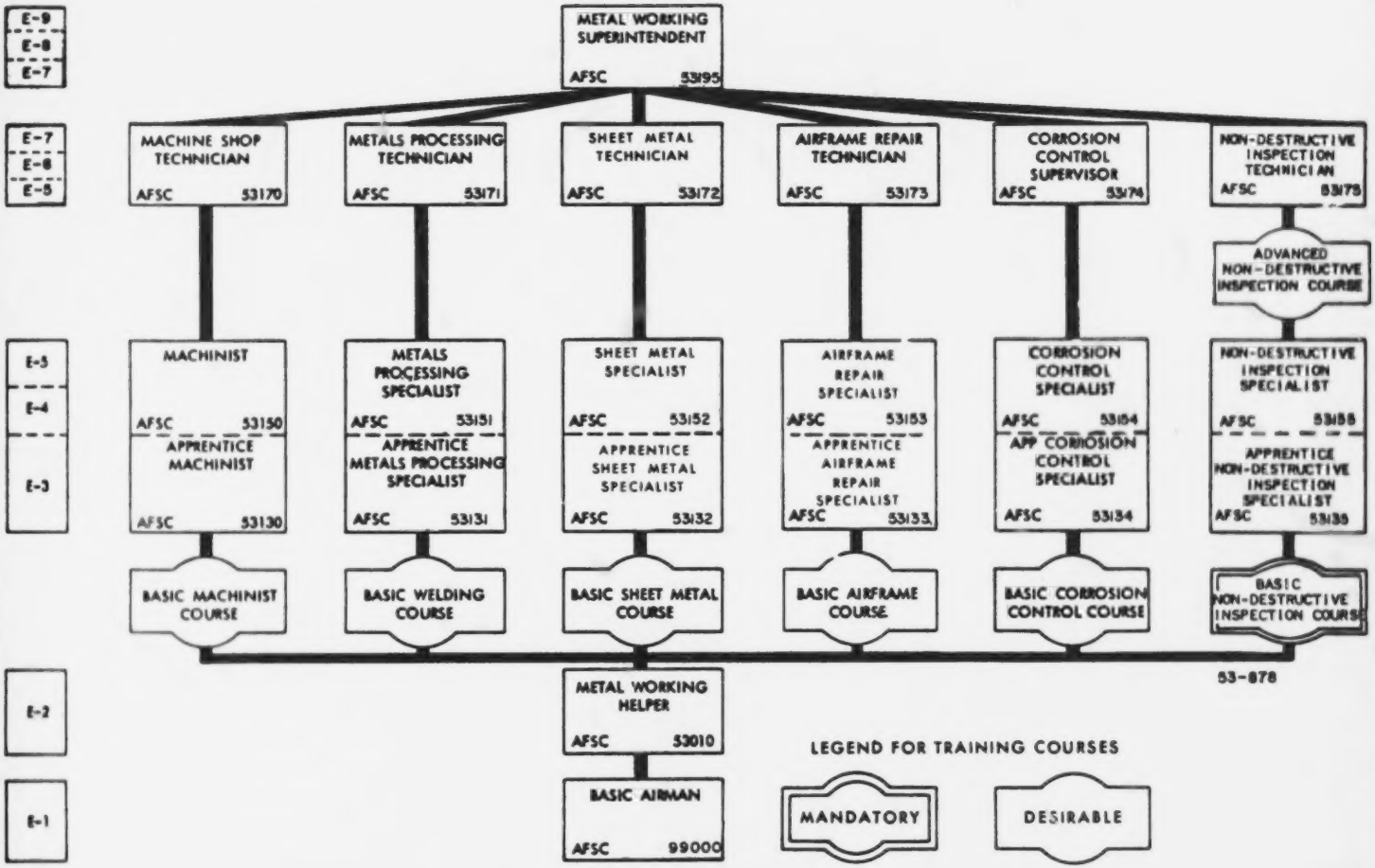

Figure 1-1. Metalworking Career Field.

002. Interpret the Air Force specialty code 531X3.

Each of the specialties within the Metalworking Career Field is identified by its own Air Force specialty code (AFSC). The AFSC numbering system consists of five digits. The first three digits identify the career field, the fourth digit indicates the skill level, and the fifth digit identifies the separate specialty within the career field.

Your career field is designated by the number 531 (Metalworking). Your skill level depends upon your advancement. An X placed in the fourth digit position does not indicate any particular skill level and is used only as a generality. The last digit (3) indicates the specific specialty in which you work. Yours is the airframe repair specialty. Therefore, a breakdown of your present AFSC is as follows:

531 — Career Field — Metalworking.
3 — Skill level — Apprentice Specialist.
3 — Specialty — Airframe Repair Specialist.

Exercises (002):

1. Identify the career field indicator in AFSC 53133.

2. What is the function of the last digit in an AFSC?

3. Which digit in the AFSC changes as you advance from skill level to skill level?

003. Cite the levels of progression in the 531X3 career field.

There are three skill levels in the airframe repair specialty; the apprentice (3 level), specialist (5 level), and technician (7 level). The apprentice skill level was awarded to you upon graduation from the basic airframe repair course. The specialist level is the level you are receiving training for now. Upon completion of all of the on-the-job training (OJT) requirements, you will be awarded the specialist level. To obtain the last level, the technician, you must be a certain rank and complete additional OJT training requirements. A complete advancement, within the airframe repair specialty, maybe traced on figure 1-1.

The metalworking superintendent (9 level), which is at the top rung of the Metalworking Career Field, is not a skill level in the airframe repair specialty or in any specialty in the metalworking specialties. For you to obtain this position, you must progress through any one of the six specialties in the Metalworking Career Field and be familiar with the other five specialties. A further explanation of this level will be given in a later objective.

Exercises (003):

Refer to figure 1-1.

1. What was your AFSC when you first entered the Metalworking Career Field?

2. Give the titles and AFSCs for each step of progression from basic airman to metalworking superintendent using the airframe repair specialty ladder.

(004). Cite the contents of AFM 39-1 and point out the purpose and function of an STS.

The skills and duties you must learn for advancement are not a "hit or miss" affair. To insure that you receive the right training at the right time, guidelines are used by the people directing the training. In time, you'll be called upon to conduct training, so it is important that you know how training requirements are developed.

AFM 39-1, *Airman Classification Manual,* is the basis for all the airframe repair training you'll receive for upgrading. It describes the duties and responsibilities for all airman AFSs at the different skill levels. We'll discuss portions of this manual as we get into the different requirements for each skill level in airframe. One thing that AFM 39-1 doesn't describe is how well you should be able to perform a certain task. Some type of cutoff point must be used so that you receive the proper amount of training as well as the right training.

Using AFM 39-1 as the source document, a specialty training standard (STS) is developed for each AFS. The STS sets the level of training you'll receive at each skill level. Your supervisor uses the STS for planning your training. As you complete each portion of the training, he'll indicate on the STS that you have reached the level of proficiency required. Figure 1-2 illustrates the proficiency code levels that are used on the STS.

You use this key to identify the proficiency required at each skill level, as shown in figure 1-3. Take a minute and study figure 1-3 and note how the training requirements increase as you proceed from one skill level to another.

Exercise (004):

1. What information is contained in AFM 39-1?

2. Why are STSs required?

3. How is the STS used for on-the-job training?

4. Why is a proficiency code key used with an STS?

You should be able to complete each operation satisfactorily with supervision. "With supervision" is the key phrase when discussing your duties as an apprentice. You are not expected to be highly proficient at these operations, nor to pass severe testing. But you are expected to try your best to accomplish each one satisfactorily. Also, as an apprentice, you are expected to assist a skilled specialist in the performance of his job, if help is needed. In this way you'll gain in experience and actually put to work the principles and procedures you're learning in this CDC.

005. List and characterize the duties of the apprentice airframe repair specialist.

As a apprentice specialist, you are expected to know the general principles of drilling, riveting, cutting, forming, and bonding of metal in the fabrication and repair of metal and nonmetal parts and components.

Exercises (005):

1. List the duties that an apprentice airframe repairman is expected to perform.

PROFICIENCY CODE KEY

	SCALE VALUE	DEFINITION: The Individual
TASK PERFORMANCE LEVELS	1	Can do simple parts of the task. Needs to be told or shown how to do most of the task. (EXTREMELY LIMITED)
	2	Can do most parts of the task. Needs help only on hardest parts. May not meet local demands for speed or accuracy. (PARTIALLY PROFICIENT)
	3	Can do all parts of the task. Needs only a spot check of completed work. Meets minimum local demands for speed and accuracy. (COMPETENT)
	4	Can do the complete task quickly and accurately. Can tell or show others how to do the task. (HIGHLY PROFICIENT)
* TASK KNOWLEDGE LEVELS	a	Can name parts, tools, and simple facts about the task. (NOMENCLATURE)
	b	Can determine step by step procedures for doing the task. (PROCEDURES)
	c	Can explain why and when the task must be done and why each step is needed. (OPERATING PRINCIPLES)
	d	Can predict, identify, and resolve problems about the task. (COMPLETE THEORY)
** SUBJECT KNOWLEDGE LEVELS	A	Can identify basic facts and terms about the subject. (FACTS)
	B	Can explain relationship of basic facts and state general principles about the subject.(PRINCIPLES)
	C	Can analyze facts and principles and draw conclusions about the subject. (ANALYSIS)
	D	Can evaluate conditions and make proper decisions about the subject. (EVALUATION)

– EXPLANATIONS –

* A task knowledge scale value may be used alone or with a task performance scale value to define a level of knowledge for a specific task. (Examples: b and 1b)

** A subject knowledge scale value is used alone to define a level of knowledge for a subject not directly related to any specific task, or for a subject common to several tasks.

– This mark is used alone instead of a scale value to show that no proficiency training is provided in the course, or that no proficiency is required at this skill level.

X This mark is used alone in course columns to show that training is not given due to limitations in resources.

Figure 1-2. STS proficiency code key.

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1. TASKS, KNOWLEDGES AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION								
	2. 3 Skill Level			3. 5 Skill Level			4. 7 Skill Level		
	A AFSC/Grs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC/Grs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials
9. HANDTOOLS AND SHOP EQUIPMENT									
SR: AFR 127-101 (chap 3); TOs 32-1-101, 32-1-151, 34-1-3									
a. Select, use, and care for handtools	2b			3d			4d		
b. Select, use, and care for special tools and equipment	2b			3c			4c		

Figure 1-3. STS task progression.

2. What is the main factor to consider when discussing the duties of an apprentice?

3. What is one way an apprentice gains experience?

006. List and characterize the duties of an airframe repair specialist.

We now reach the area that concerns you the most at this time—the duties of the specialist. We can discuss these duties by looking at the specialty summary for the airframe repair specialist listed in AFM 39-1.

AFM 39-1 states that, as a specialist, you should be able to "repair, modify, and fabricate aircraft metal, plastic, fiberglass, and honeycomb structural parts, components and assemblies." As you can see, the verbs are all active verbs, indicating that you perform. You should be able to complete each of these tasks with a far lesser degree of supervision than the apprentice. In fact, certain tasks that you should be able to perform, without supervision, are an indicator of your experience and training. The specialists are the people who do most of the work of the shop. Along with these duties comes your introduction to supervision. Even though most of your duties involve your doing the work, there will be times when you'll be required to supervise people. Team leader of repair crews and conducting phases of on-the-job training are two examples of situations where you'll be accountable for other people. The supervision that you perform as an airframe repair specialist will be good experience. You will need and use this experience as an airframe repair technician.

Exercises (006):

1. Where is the emphasis placed on the duties of an airframe repair specialist: knowledge, performance, or supervision?

2. List briefly the duties of an airframe repair specialist.

3. Why should you be concerned with supervision at the 5 skill level?

4. What types of supervision will you perform as an airframe repair specialist?

007. Identify technician positions and select from a list of duties those that are required of an airframe repair technician.

The specialty summary, in AFM 39-1, states that the technician "accomplishes major aircraft structural repairs; troubleshoots structural repair situations; inspects repair operations and completes repairs of metal, plastic, and bonded structural components; and supervises airframe repair activities."

As you can see, performance is still emphasized as it was for the specialist. The perfomance of the technician demands a higher degree of technical skill than that of the specialist, and a technician must also be well balanced in the knowledge and supervisory areas. The specialty summary points out that the technician supervises airframe repair activities. Because of his supervisory capability, a technician is often assigned as an airframe repair shop or shift supervisor.

Exercises (007):

1. What is the AFSC for an airframe repair technician?

2. State two positions to which a technician may be assigned.

3. In the space provided indicate whether a duty pertains to an airframe repair technician by placing the word "no or yes."

_____ a. Performs welding of bonded structures.
_____ b. Supervises airframe repair activities.
_____ c. Assists airframe repair specialists.
_____ d. Accomplishes major aircraft structural pairs.
_____ e. Heat-treats metals.

008. Point out the duties of a metalworking superintendent and give his AFSC and rank required.

We now come to the top rung of your career ladder, the metalworking superintendent (53195). In a field maintenance squadron, the metalworking superintendent is usually the Fabrication Branch Chief. The shop supervisors work directly for him.

The metalworking superintendent's duties are primarily in the areas of supervision and management. The specialty summary states that he "superintends activities engaged in testing, fabricating, repairing, and machining metals and metal products; corrosion control in missile, aircraft, and support system equipment; and nondestructive inspection of aerospace material parts, components and pressurized systems."

It is evident that the metalworking superintendent's duties and responsibilities are even more supervisory in nature than those of the airframe repair technician. Because of his supervisory responsibilities, a metalworking superintendent must be at least a master sergeant.

Exercises (008):

1. What is the AFSC of a metalworking superintendent?

2. What rank must a man hold before he can obtain the superintendent position?

3. Where is the emphasis placed in a metalworking superintendent's duties?

4. Circle the letters which represent the duties and responsibilities of a metalworking superintendent.

a. Assigns specialist jobs within a shop.

b. Directs metalworking activities.

c. Conducts on-the-job training for apprentice specialist.

d. Supervises shop supervisors.

e. Performs major repairs.

1-2. Communication Security

The degree to which you will be involved with security depends on the mission of your base, the type of equipment for which your base is responsible, and the location of the base. You may be involved with security quite often in your work, or you may seldom be involved with it. Regardless of the degree of involvement, every person in the Air Force, military and civilian, must be security-conscious. The person who works with classified information only occasionally can be a potential source of danger, simply because he is less aware of the importance of safeguarding security information.

009. Given items of information, identify each as classified, unclassified, or of possible intelligence value.

Classified information is official information, the safeguarding of which is necessary in the interest of national security. Unclassified information is information that does not require use of security safeguards, but its disclosure may be subject to control for other reasons. The target for a strategic bomber wing is classified information. The number of bombers from that wing that are on the flight line is unclassified information. However, if those bombers are being loaded with a certain type of bomb, their number becomes of possible intelligence value.

A bit of unclassified information alone may not be of any intelligence value, but when it is combined with related information, giving insight into a classified

plan, each bit of information has possible intelligence value.

Keep in mind these three kinds of information: classified, unclassified, and of possible intelligence value. Always keep quiet about any job-related information, regardless of how or where you obtained it.

Exercises (009):

1. A master target plan for strategic missiles is _____ information.

2. The fact that the Air Force has sent Captain Jones to an area of undeclared war is _____ information.

3. Captain Jones is a demolition expert. Is this statement classified or unclassified?

4. Combining the information in question 2 and 3 produces information _____

010. Given examples of official information, give the security clearance required for each.

The basic regulation that covers security is DOD 5200.1-R, *Information Security Program Regulation.* Classified information is official information that must be safeguarded in the interest of national security. Unclassified information is official information that does not require safeguarding but may be subject to control for other reasons. Some unclassified information requires control in the public interest and is thus labeled "For Official Use Only." This means that it must be withheld from widespread distribution to the public. Examples of this type of information are notification of a shipment and personnel records. Both of these are unclassified but are For Official Use Only.

Classified Information. Security information is classified according to its importance. The highest classification is given the greatest amount of protection. The three categories of classified information in the order of their importance are as follows:

(1) Top Secret (TS).
(2) Secret (S).
(3) Confidential (C).

Quoting from DOD 5200.1-R, supplemented by AFR 205-1, Section B, Chapter 1, these categories are used as follows:

(1) Top Secret refers to that national security information or material which requires the highest degree of protection. The test for assigning Top Secret classification shall be whether its unauthorized disclosure could reasonably be expected to cause *exceptionally grave damage* to the nation security.

(2) Secret refers to that national security information or material which requires a substantial degree of protection. The test for assigning Secret classification shall be whether its unauthorized disclosure could reasonably be expected to cause *serious damage* to the national security.

(3) Confidential refers to that national security information or material which requires protection. The test for assigning Confidential classification shall be whether its unauthorized disclosure could reasonably be expected to cause *damage* to the national security.

Exercises (010):

1. Information that may lead to an armed attack against the United States or its allies is identified as _____ information.

2. Your hospital records are what type of information?

3. Information that is not in the best interests of the national security is classified as _____ information.

011. Indicate the physical security practices related to classified information.

Physical Security. Physical security deals with the handling and storage, transmission, and disposal of classified military information. This information may be in the form of documents, messages, or equipment. Carbon copies, rough draft, or paraphrases of original documents must also be safeguarded. The possession or use of classified material is to be limited to locations where the prescribed facilities are available for its secure storage or protection. Every person who works in a shop where there is classified material should know how to handle and store it. Classified material is handled *only* by authorized personnel who have a need for the material. It should never be discussed with unauthorized personnel. Storage requirements vary according to the security category and the type of material. At the end of normal duty hours, each safe, vault, or vault type room is inspected to insure that it is properly locked.

A safe or other safe-type container that is used for the storage of classified material should contain classified material only. Money, drugs, and other valuables should never be palced in a safe used for the storage of classified material.

Although you may never be assigned the responsibility for classified documents at any time during your military service, it is quite likely that you will find yourself in possession of classified knowledge at some time or other. This may occur through attendance at a conference, overhearing a conversation, or being exposed to classified material in the performance of your regularly assigned duties. It is for this reason that the entire matter of security as it relates to classified documents and material has been discussed. In other words, we want you to be security conscious. Then you are not likely to be guilty of even the most common security violation.

The majority of security violations are usually the result of carelessness rather than ignorance. Errors resulting in security violations can be found under any of the following basic categories: (1) unprotected papers and materials, (2) unlocked or open safes, (3) lost or misplaced documents and material, (4) failure to classify materials properly, (5) unauthorized disclosure of classified material, and (6) mailing violations. You must know where your classified material is and how it is stored.

We cannot overemphasize your obligation to safeguard military information. This is a personal responsibility that belongs to everyone whose job in any way involves the defense of the United States. You cannot exclude yourself from this responsibility regardless of what type of work you are doing in the Air Force. To use the excuse that as an airframe repair specialist you will *never* be confronted with this type of information is entirely wrong. You must remember that you are a part of the United States Air Force and that it is your responsibility to know about security.

Exercises (011):

1. Who has the right to handle classified material?

2. What factor determines where classified information can be used?

3. How could you, as an airframe repairman, be exposed to classified information?

4. What items are not stored with classified materials?

5. What factors determine the storage requirement for classified materials?

012. Distinguish between the methods of transmitting classified information in terms of types of information and advantages and disadvantages of each method.

With a knowledge of the classifications of official information, let's examine the various ways it is transmitted. For information to be useful in the conduct of official business, it must be passed from one person or place to another. Mail, telephone, radio, and messenger are modes of communication, as well as telegraph, television, and signals. We will discuss only transmission by mail, telephone, radio, and messenger. Each method has certain advantages and disadvantages.

Mail. Within our country, mail handled only by the United States Postal Service is given some protection. Registered mail, especially, requires special handling by the postal service. When the mailman brings you a registered letter, you must sign a receipt. The advantages of using mail are that the information is somewhat protected, it is inexpensive, and registered mail is documented. The disadvantages of mail service are that it is slow and mail can get into the wrong hands. Only information that is classified as Secret and below can be sent by mail.

Telephone. The telephone is a very convenient mode of communication. Two advantages of the telephone as a mode of communication are its convenience and speed. A major disadvantage of using the telephone is that conversations are easy to monitor (listen in on). The telephone must not be used for transmitting classified information or information of possible intelligence value.

Radio. In radio communication, an antenna sends radio waves through the air. If secret codes and ciphers are used to encrypt classified information, radio is a secure mode of communication. Radio, like the telephone, has the advantages of convenience and speed. Its disadvantages are that the sender has no way of knowing who is listening to his conversation, radio messages are easily monitored, and the equipment is sometimes not dependable.

Messenger. Information sent by messenger is handcarried from the sending office to the receiving office. The advantages of the messenger service are that the material is secure, receipts are required, and the material is not subject to inspection. The disadvantages of using a messenger are that the service is slow and expensive.

Exercises (012):
Match the methods of transmitting classified information listed in column B, with the statements listed in column A.

Column A	*Column B*
_____ 1. Secure methods of communications.	a. Mail.
_____ 2. Method is slow and expensive.	b. Telephone.
_____ 3. Used only for Secret and below categories of information.	c. Radio.
_____ 4. Methods are easily monitored.	d. Messenger.

013. Point out requirements concerning the release of classified information.

We have just discussed transmission of classified information by various modes. However, certain requirements must be set up before it is released, either in discussion or transmission.

Before discussing, permitting access to, or transmitting classified information, the intended recipients must be completely and undisputably identified. Their "right and need to know" should be clearly established. If a personnel security clearance is prescribed as a prerequisite for access to the information involved, the clearance of the intended recipients must be verified before permitting access to that information. The recipient must have a security clearance equal to or higher than the classification of the information to which he desires access.

By identifying the security clearance of the recipient, you establish his right to know. But, as we said earlier, he must also have a need to know. He must need the information for the performance of his duty and not just because he wants to know it. Even if you have the proper security clearance, you must still have the need to know. This is also true in reverse. Though you have a need to know, you must still have the security clearance required.

The Air Force regulations covering security of information are all in the 205 series based on DOD 5200.1-R.

Exercises (013):
1. What must be established before access or discussion of classified information is permitted?

2. Major Brown has a verified Top Secret clearance but he needs Secret information. Should he be allowed access to the information?

3. Captain Jones needs certain Top Secret information, but he has a Secret clearance. Should he be allowed access to the information?

CHAPTER 2

Supervision and Training

THE AIR FORCE works on the principle that each members be able to lead as well as follow and every member must be trained to supervise. This should answer your question "Why am I studying supervision principles when I'm only a 3 level?" Good supervisors are not born; they must be trained. This chapter on supervision is just a small segment of the training you will receive concerning the concepts of supervision during your career.

One of many duties of a supervisor is training. Your role in training changes from time to time. One time you'll be receiving training, and at other times you will be conducting the training. Training is a never ending part of your military career. As a supervisor, developing the worker's job proficiency by on-the-job training and recording the results accurately are supervisory responsibilities. In this chapter, we will discuss important principles that should help you receive supervision and training, and when called upon, supervise and train others. In reading this chapter, put yourself in the place of your supervisor. Compare the principles and concepts to the "real life" situations you have encountered in your shop. Then decide, is your supervisor meeting the standards of a good supervisor?

2-1. Supervision

Webster defines "supervision" as "critical watching and directing." This is a very simple definition of the word. In the Air Force, supervision is not only watching and directing but also coordinating, planning, assigning, evaluating, justifying, and counseling. We will discuss all of these interrelated principles in the next objectives.

014. Identify some of the personality traits associated with a good supervisor and cite applications of leadership qualities.

Leadership Qualities. The qualities of leadership separate good supervisors from poor supervisors. You can know all there is to know about a specialty, but if you are lacking in the ability to lead, you are in for trouble. A leader is more than a director. He is not only a supervisor but a manager. Not only does he guide his subordinates; he also commands their respect. He lays out the details of a job, assigns and advises his workers, assembles equipment and materials, and accounts for the time of the workers and the material they use. Effective management and leadership create a willing, cooperative, progressive, and continuously improving work force.

A leader has personality traits that are admired by his subordinates. To become a true leader, you must recognize these and strive to attain them. Some of the personality traits of a good leader are given below.

Friendliness. Be friendly toward the people who work for you, yet retain their respect for your ability and leadership. Don't be noticeably more friendly toward some people than others.

Initiative. Have the ability and willingness to start new projects. Enjoy your work, and project your enthusiam to others.

Ability to make decisions. Make decisions based upon careful reasoning. Be able to admit it when you don't know the answer. Don't pretend to know an answer when you don't.

Interest in people. Be interested in people. Listen sympathetically to their problems and make an effort to understand them.

Understanding. Realize that a person may not be at his best all the time and that trouble at home or outside worries can effect anyone's efficiency. Understand that your people are individuals.

Sincerity. Don't simulate friendliness and interest. Don't be a "hyprocrite." Make complimentary comments only when you really mean them. Identify yourself with your people to the point that you will fight for them, even in their absence, provided they are in the right.

Pride in accomplishment. Have a sincere desire to see that your people do good work, not a fear that they will become as proficient as yourself. You should want your people to succeed and be proud when they do. Don't be afraid of your position, your subordinates, tough jobs, or honest mistakes. Convey the impression that you are trying to work yourself out of a job and your people into it.

Patience and emotional control. Never assume that because a task is easy for you, it is also easy for everyone else. Realize that the person to whom you must explain a task several times may later perform the job much better than the fast learner. Control your

temper and think before you speak. A worker may hold a grudge a long time because of words spoken too hastily—and a worker with a grudge won't be as efficient. When necessary, give constructive criticism without losing your temper. When things go wrong on the job, appear calm and unperturbed and do not get frustrated. Straighten out problems with as little fuss as possible.

Fairness. Don't deal out favors to those who feed your ego. Establish fair production standards; don't require one person to complete a big job in the same time that you give another person to complete a small job. When you evaluate a person, rate him on actual performance (production and quality) rather than upon his friendly overtures to you.

Your personality is the sum of those traits that you demonstrate when you are with others. Your personality is most attractive when you have entirely forgotten yourself. Think of the other person as a distinct individual, one whom you will try to understand and help. The best rule of action is the Golden Rule: Do unto others as you would have them do unto you.

Exercises (014):

1. What factor separates good supervisors from poor supervisors?

2. Select, from the list below, the essential traits of a good leader:
   a. Sincere.
   b. Strong.
   c. Friendly.
   d. Indecisive.
   e. Patience.
   f. Tall.

3. Effective management and leadership creates what type of work force?

4. How should you, as a supervisor, practice fairness when evaluating a person's performance?

5. In understanding workers, what factor must be foremost in the supervisor's mind?

015. Outline the techniques of good human relations when supervising workers.

Just by being "Mr Personality" doesn't insure your success as a supervisor. How well you use your talents when dealing with people will determine your success or failure. Over the years techniques have been developed to aid the supervisor in dealing with workers. These techniques apply to people in general but do not lose sight of the individual. The following techniques will assist you in your efforts to help the workers adjust to their jobs and form an integrated and cooperative work force.

Let Each Worker Know Where He Stands. All workers need to know they are getting along well if they are to be happy and satisfied with their jobs. They should know whether they are doing a good job or not. How can we do this? We can take an interest in our workers and get to know each one personally. We can have periodic talks with each worker and see that each knows his job requirements. How often you contact your workers and how close the personal relationship should be depends upon your individual work situations. There is a delicate balance between overfamiliarity and friendship. As a supervisor, you must walk the fine line of propriety or risk severe criticism, which can be very damaging to morale and productive output in your unit.

Give Credit When Due. This is another technique to guide the supervisor in his job relations with his workers. Experience has proven that giving credit when it is deserved will get good results. We know that the supervisor who ignores this practice will create problems that will cause lagging interest among the workers, but knowing the technique and knowing how to put it to use are two different things. Give credit when due is a good idea— but how do you do it? There are many ways. Here are some of them: (1) give a man a pat on the back and a little praise when he does a good job; (2) use letters of appreciation and commendation; (3) recommend outstanding performance ratings; (4) use both the military and civilian suggestion programs which may give cash awards and other forms of recognition for improvements developed by your people; and, finally, (5) do not overlook the very important method of recommending personnel for promotion, upgrading, and better assignments.

Inform Workers in Advance and Let Them Participate in Planning. Supervisors can inform their workers of changes by personal contact with each individual, by written notices and bulletins, or by informal meetings and discussions. The latter is a good method, but just calling workers together in a meeting does not automatically win their support and approval of changes. The supervisor still has the problem of getting their interest and participation. He must do something to make the workers want to take part in planning for changes. He must encourage them to contribute their ideas and "pitch in" to meet the problems. It is the supervisor's attitude and conduct in general that make workers willing to cooperate.

Gain the Worker's Confidence. Some ways to gain the worker's confidence are to take a personal interest

in him, to be friendly, helpful, and fair in your dealings; to encourage the worker to come to you with his problems; and to take actions on the problems if at all possible.

We have discussed ways of putting human relations techniques into practice. These are by no means all of the techniques that a supervisor will use. However, those discussed are of major importance and, when used properly, will be of great assistance to a supervisor.

Exercises (015):

1. Why is it important to let a worker know where he stands?

2. List three ways of giving credit due a worker.

3. What factors affect the amount of cooperation workers are willing to give?

4. How can a supervisor gain the worker's confidence?

016. State why supervisors are needed and cite factors that influence the selection of techniques used to give directions to workers.

Up to this point, our discussion has centered around the supervisor. Now it's time to proceed into the duties and responsibilities of a supervisor. First, let's examine the need for good supervisors.

Need for Supervisors. The supervision of airframe repair personnel is essential for mission completion and personnel safety. The mission is the role that the Air Force has in our Nation's defense system. The goal of every one of your duties is the completion of work, performed correctly, and on time. Safety goes hand-in-hand with work accomplishment and is of prime concern in any work situation. Good supervisors establish work methods and controls to reach this goal. Providing good directions to your worker is a sure way of attaining this goal.

Techniques of Directing. The workers in a typical airframe repair shop vary greatly in proficiency. The supervisor's directions can take the form of a command, a request, or a suggestion, depending upon the situation and the individual worker's proficiency and personality. You usually use the command method to handle an emergency, to maintain strict control, and to obtain immediate action. Requesting is the best method for normal situations; it is human nature to prefer being asked to do something rather than being told to do it. Suggesting is a good method—if it gets the job done. You can often use it to good advantage to stimulate initiative, to direct highly competent workers, and to direct workers who readily accept responsibility.

Consider the following approaches to direction: (1) directing as a two-way process, (2) giving good directions, (3) oral and written directions, and (4) the attitude of the director.

Two-way process. When giving your directions, you should know your subordinates' capabilities and workload. You are responsible for providing the equipment, material, and supplies they need to carry out your directions. If you fail to consider your worker's present workload and the material he needs to work with, you have wasted his time and lost his respect. You can probably recall examples of poorly planned orders.

The supervisor must also make sure that his workers understand his directions. When you give an order, make sure it is understood. If the worker has any questions about his assignment, he should let you know. This interchange of information leads to a better understanding and appreciation of the situation involved for you as well as for the worker. Thus, you can see that good directing is a two-way process, resulting in improved performance and harmonious relations. In the absence of this two-way process, confusion and irritation are almost sure to develop.

Giving good directions. The framework for most of your shop operation is provided by regulations, manuals, and technical orders. Use these controlling directives as guides when you direct the work of your subordinates. However, there are situations that call for decisions and directions that are not covered by these directives. In these cases, you must issue your own directives, using your organizational objectives and good judgment as guides.

As we have already pointed out, you may demand, request, or suggest, depending upon the worker and the task, but in every case, you must be reasonable and fair.

Oral and written directions. Directions are given either orally or in writing. Each method has its uses. For example, it is foolish to put short, simple directions into writing and to give long, complicated directions orally.

Here are some guidelines to help you determine which type of directive to use:

a. Oral directions are usually used to:
   (1) Explain minor details.
   (2) Give assistance.
   (3) Clarify a written order.
   (4) Give instructions in an emergency.
   (5) Stimulate worker interest.

b. Written directions are usually used to:

(1) Control work in another location.

(2) Give orders involving precise specifications or complicated details.

(3) Hold a worker strictly accountable.

(4) Control work in which the order of performance is important.

Remember that any directive can be misunderstood, whether written or oral. Always ask your workers if they have any questions.

Attitude of the supervisor. Perhaps you have seen a supervisor give an order and suggest by his attitude that the order is unimportant. For example: "The chief wants us to count all those parts in the bench stock again. Take care of it as quickly as you can so that we can get at something worthwhile. Here's a copy of the count we made last week if you want it!"

It is not hard to picture the attitudes of the workers assigned to this job. You can almost guarantee careless work. A person must believe in the importance of the work he is doing if he is going to do it well and enjoy doing it. You must feel that there is value in the directions you give if you expect your workers to do their job well. Sometimes you must assume that the chief knows more than you do, perhaps more than he can tell you.

Exercises (016):

1. State the chief reasons for supervising airframe repair personnel.

2. What is the prime concern in any work situation?

3. Human nature prefers what type of direction?

4. When are written directions given?

5. When are oral directions given?

017. Identify the six basic steps to follow in resolving personnel problems.

Resolving Personnel Problems. If everything went as planned, there wouldn't be a need for supervisors. A computer would issue directions and the worker would go about doing his job. But people, supervisors and workers alike, have one main fault in common: they are human. The human element must be considered in any undertaking. No matter how well you plan an operation, problems are going to occur that must be settled before any goal can be reached.

If everyone solved problems in exactly the same way, everyone would have the same thought processes. Although people do not think alike, all of those who are capable of finding proper solutions quickly and easily do have something in common. They follow a well-established pattern of thought and action. There is no trick or magic formula for solving problems, but those who are most successful follow an orderly, organized process:

- Define the problem.
- Establish objectives.
- Gather facts.
- Weigh and decide.
- Take action.
- Evaluate action.

Let's look at each of these steps in more detail to understand how all six steps function as one unified and successful process.

Define the Problem. When trouble arises, we say that we have a problem. But if someone asks us, "Just what is your problem?" we often find it difficult to put it into words. Yet, if we cannot state the situation clearly, it is hard to know exactly what we want to achieve. Defining your problem clearly leads you into setting objectives. For example, a supervisor is faced with what seems to be a problem of absenteeism. Further study of the situation reveals that the real problem is transportastion, housing, epidemic influenza, or even the world series. The problem of a high percentage of spoiled work could represent a problem of forced machine speeds, poor materials, lack of training, or a number of other problems.

Establish Objectives. What do you want your solution to accomplish? Sometimes your objective is obvious. The supervisor with the problem of absenteeism wants to eliminate absenteeism. The supervisor with too much spoiled work wants to reduce his percentage of throwouts and increase his percentage of completed work. The objectives in a problem situation are not always to obvious and must be carefully thought through. The end result of your problem-solving exercise may not be the same as the objective you chose in the beginning, but, from the moment you know what your problem is, you must have a goal toward which you are moving.

Gather Facts. To solve your problem, you need to know the whole story. You can do this only by securing as much information as is possible in the time available. It is poor management to make a decision without sufficient facts. Even though a decision must be made on the spur of the moment because of the pressure of time, every possible attempt must be made to get all of the information that should be known before the decision is made.

There are a number of sources from which informa-

tion can be obtained. Perhaps records, rules, regulations, and customs apply. Workers who are concerned with the problem may be better informed about the situation than the supervisor. Their opinions and feelings may actually constitute the facts of the problem situation. The supervisor can gain information by listening to workers talk about the situation, keeping his eyes open and observing what is happening, and asking questions.

One question that may seem puzzling is this: "How can a person tell when he has gathered all the significant information?" This is a matter of judgment. If the facts that you have assembled begin to fit together into a pattern, you can see areas where you still lack specific facts and where some facts you have collected do not apply.

With your "pattern" complete, you are ready to select tentative solutions. But before you discard any facts as irrelevant, it is important that you really think about them. Sometimes important solutions, even discoveries, are made by a person who can find the relationship between facts that others have passed over as unimportant.

Weigh and Decide. Now you must fit the facts together and consider their bearing on each other. Ask such questions as: What caused this to happen? Who was responsible there? Did this happen before or after that? As you think about the problem and analyze the facts, possible solutions will occur to you. List every reasonable solution for careful review. Anticipate the results of each possible solution to determine its effect on individuals, groups, production, etc.

This process enables you to select the best action to take because you will be able to identify the action that will achieve your objective. Consider how your solution relates to time, money, equipment, supplies, and other resources.

Take Action. Up to this point we have discussed ways to make a sound decision. Now you must act. All of the effort and time spent in arriving at this decision is wasted if favorable action does not result. When you take final action on a problem, consider these questions: Should I handle this myself? Do I need help in handling it? When and where should the final action be taken?

Evaluate Action. Sometimes the best laid plans and the most carefully made decisions do not work out exactly as anticipated. Maybe you didn't get all the pertinent facts, or some of your information was false or misleading. Therefore, it is essential that you check on how your solution is working out. Now is the time to make corrections.

Exercise (017):
Match the individual problem solving steps listed in column B with a statement listed in column A by placing the letter of the individual step in the space provided.

Column A	*Column B*
____ 1. One course of action a supervisor can take to meet this problem solving step is observing what is happening.	a. Define the problem.
____ 2. The most difficult portion of problem solving.	b. Establish objectives.
____ 3. This step must be flexible to meet changing situations.	c. Gather facts.
____ 4. This step involves anticipating the results of each possible solution.	d. Weigh and decide.
____ 5. This step involves making corrections.	e. Take action.
____ 6. This step is one in which you decide if you need outside help or not.	f. Evaluate action.

018. Categorize types of coordination, and given a work coordination problem, state the action you should take.

All problems are not confined to your individual shop. Sometimes situations develop that require a combined effort by a number of shops or coordination with higher levels within the maintenance complex. Coordinating is working with people and keeping everything in balance within your shop and with outside activities. As a supervisor, you are involved in two types of coordination: vertical and horizontal.

Vertical Coordination. Vertical coordination extends from you, the supervisor, up through your superiors to the Chief of Maintenance. The following is an example of vertical coordination.

Assume that your shop, during the past 3 months, has been unable to complete three critical work orders on schedule. You believe that the cause of this problem is a sharp increase in airframe repair work requiring a high degree of skill and that the assignment of another specialist to the shop would solve the problem. You bring the matter to the attention of the metalworking superintendent, who is not convinced that a request for an additional specialist can be justified. You decide that you should get concrete evidence of the need for another highly skilled worker in the shop. You suggest to your superintendent that the maintenance control section could help by reviewing the maintenance collection system data for the past 6 months. He accepts your suggestion. The maintenance control section supplies you with statistical evidence that proves that there has been a sharp increase in the type of airframe repair work that requires a high degree of skill and gives you the number of man-hours used to complete that work. You are then able to submit to your superintendent a request with written justification for the assignment of another specialist. You succeed in enlisting the support of

both the superintendent and the Chief of Maintenance, and approval is granted. This is an example of vertical cooperation in solving a problem. You recognized a problem and took the initiative in solving it. You provided concrete evidence that enabled your superiors to make decisions.

Horizontal Coordination. Horizontal coordination extends from you, as supervisor, outward to supervisors of other shops. You may find that coordinating with the supervisors of other shops is more difficult than coordinating with persons above your level. You and the person involved may have a personality conflict. This is when experience and tact play an important role.

Vertical and horizontal coordination must be kept in balance. If you spend too much time on vertical coordination, your subordinates may regard you as an "apple polisher." On the other hand, if you spend too much time on horizontal coordination, your superiors may regard you as uncooperative.

Exercises (018):

1. You are the shop supervisor and are advised that another shop needs assistance on a high-priority work request. The only specialist you have available is working on a lower priority job, which you coordinated with your superiors, to be completed as soon as possible. What do you do?

2. Why must you, as a supervisor, coordinate both vertically and horizontally?

019. Name the factors to consider in planning and scheduling work assignments, and, given two job requests, determine the one that should have the higher priority.

Planning, Scheduling, and Assigning Priorities. Planning, scheduling, and assigning priorities are a part of a supervisor's duties. We will examine each of these activities.

Planning. Planning is deciding the best course of action to achieve an objective (mission). To prepare a shop work plan, you must consider these main factors: the size of workload, the number of people assigned and their skill levels, and the equipment available.

Scheduling. Scheduling is very closely related to planning but is not the same. Planning is deciding on a course of action whereas scheduling is setting this plan into a time table. To establish this time table, you must consider certain factors that are directly related to those used in planning. These factors include the skill level of your workers, the available equipment, the simplicity or difficulty of the job, and— most important— the priority of the job. If the worker is sufficiently skilled, has the proper equipment, and has no problems, the job will be completed on schedule. However, if problems arise or the job is too complicated for the worker, the job will be completed behind schedule.

Priority. As we mentioned previously, job priority is an important factor in scheduling. The priority is an important factor in scheduling. The priority of a job is determined by the effect it has upon the mission. The more essential the mission, the higher the priority. For instance, if your mission is fighter support, then your highest priority jobs directly involve the fighter aircraft.

As you can see by our discussion, all plans, schedules, and priorities are directly related to production (mission). Your production is directly related to you as a supervisor and to your planning and scheduling. Mission accomplishment is the first responsibility of the supervisor. The supervisor should always be "mission-minded."

Exercises (019):

1. What factors must you consider when you are planning work assignments?

2. As you plan, schedule, and assign priorities, always keep in mind your _____ .

3. Two job requests are given to you for priority assignment. One is for the repair of the General's flagstaff; the other is for the repair of an aircraft part. Which should receive the higher priority?

020. Indicate the contents and use of maintenance and inspection reports and charts.

Reports. One prime source of valuable data that will aid you in your planning aspect of supervision is maintenance and inspection reports. They are published monthly or weekly, broken down into a day-to-day account of what has taken place in the maintenance complex. Examples of the information found on them are: flying requirements, what maintenance is scheduled, and inspection results. Additional information can be added, depending on the situation.

This information has a direct bearing on how you manage your people. If you know "X" number of aircraft are schduled to fly on a given day, you must have enough personnel to meet this requirement. The

same holds true in regard to scheduled maintenance, such as phase inspections (docks), time change items, and technical order changes that must be accomplished. Time off and leaves must be closely monitored to insure you have the required number of personnel on hand. Also, supplies must be ordered for known scheduled maintenance. Sometimes supplies are not readily available on base and must be ordered by base supply. It usually takes a few days to receive these supplies. These reports provide you with maintenance dates, so you're able to order in plenty of time the necessary supplies. Preplanning like this eliminates the embarrassing situation of having to explain why necessary supplies are not on hand when you knew ahead of time about the scheduled maintenance.

The inspection section of the report outlines the results of inspections conducted by quality control (QC) and safety. They indicate satisfactory areas and areas that need improvement. The quality control portion deals with the quality of workmanship. Are technical order procedures being followed? Is the maintenance being accomplished up to established standards? These are just two of the areas examined. The safety portion points out safety violations while maintenance was being accomplished. The supervisor uses these portions of the report for making improvements within his area. Additional training and safety briefings might be the answers. Each supervisor must evaluate these portions of the reports to improve the performance of his personnel.

Charts. In-shop record keeping is another source of planning information. When you perform maintenance on a piece of equipment or inspect it, you record what you did on a chart so that later you can review what was done. The charts can point out mistakes, the date of the last inspection or repair, and the possibility of future trouble. They can identify present requirements and predict future needs. A careful analysis of past records can prevent future maintenance actions. In-shop records and maintenance and inspection reports used properly save the Air Force money and time.

Exercises (020):

1. List examples of the information found on maintenance and inspection reports.

2. How should the supervisor use the quality control and safety portions of the inspection reports?

3. Besides the maintenance and inspection reports, what is another source of information the supervisor should consult for planning purposes?

021. Specify whether given statements concerning the justification of shop personnel and equipment are correct.

Personnel and Equipment Justification. When you begin your first day as a shop foreman, your primary concerns will probably be the size of the workload, the number of people assigned, and the amount of equipment. Your primary objective will be production—completing work orders. The number and the skill level of the people and the amount of equipment authorized for your shop were determined by the mission of the airbase.

Assume that, as you begin your duties as a foreman, the shop has a big backlog of work orders. You must find out if the recent flow of work has been abnormal. It is normal for the amount of work flowing into a shop to vary from week to week. Perhaps it will level off in a few days. Do not conclude immediately that the number of people and the amount of equipment authorized are inadequate. Perhaps the number of people assigned is correct, but their skill levels are below those authorized. Suppose that the manning document authorizes one technician, four specialists, and seven apprentice specialists for your shop, but one technician, two specialists, and nine apprentice specialists are assigned; you have enough people, but they do not have the skills authorized for the shop.

NOTE: Unauthorized skill levels do not justify additional personnel. However, if this is the key to the problem, the solution is either to request the metalworking superintendent to assign two more specialists or to provide the training that will enable at least two of the apprentices to qualify as specialists. You must decide on the best course of action.

If you decide that you need two more specialists you must supply statistical evidence to justify the increase in manning. You must submit your request with written justification to your supervisor to obtain these individuals. The justification is necessary to insure that a shop does not become overpopulated for the amount of work it is normally assigned. Overpopulating a shop in relation to its workload is a waste of Air Force dollars and is bad management.

The key to the problem of the big backlog of work orders may not be the fluctuation of the work flow or an inadequate number of workers, but insufficient equipment in the shop. Perhaps there is an adequate amount of equipment, but it is not in good operating condition. Either of these situations requires justification for ordering new or replacement equipment.

Exercises (021):

Indicate in the space provided whether a statement is true or false by placing the letter T or F.

_____ 1. The number of skill level personnel in a shop is directly related to the mission of the airbase.

_____ 2. The amount of equipment authorized in a shop is related to the number of personnel in the shop.

_____ 3. In order to justify additional personnel in a shop, statistical evidence is needed.

_____ 4. Unauthorized skill levels in a shop justify additional personnel.

_____ 5. The amount of work received in a shop during a 1-week period is justification for an increase or decrease of shop personnel.

022. Cite errors in specific applications of the principles of organization.

Principles of Operation. In order that an airframe repair shop can meet its mission requirements, it must be organized. The supervisor has a key role in the setup and operation of the shop. There are four principles of organization that will aid you in organizing a productive situation.

Unity of Command. Each person in your shop should have only one "boss." This is the person to whom he reports and from whom he receives his directions. This means that, as a supervisor, if you assign specialists to work for a technician, he becomes their boss. They report to him and he reports to you.

Span of Control. Span of control is the number of people you can supervise effectively. According to this principle, you can effectively supervise only three to seven workers. For example, if you have three specialists and six apprentice specialists in your shop, you can divide the workers into three groups with a specialist and two apprentice specialists in each group. By directly supervising only the specialists, you reduce your span of control from nine to three workers. Distance is also a limiting factor. At the same time, you may have some of your people working in the shop, some on the flight line, and some at another part of the base. You could handle this situation by assigning three specialists, each one to supervise the work of one of the groups—limiting your span of control. Other factors limiting span of control are the nature of the work and the skill of the worker. Simple tasks and skilled workers require less direct supervision; complicated tasks and unskilled workers require more direct supervision.

Logical Assignment. This principle controls the assortment of tasks in a worker's assignment. They should be related. The grouping of his duties should make sense. If you assign a man to repair complex machinery and do your typing, his assignment is illogical. The separate activities in his assignment should require generally similar skills at the same skill level.

Delegation of Authority. When you assign to an individual the responsibilities of a position, you must delegate to him the authority to complete the tasks in that position. As supervisor of your unit, you are responsible for it. Though you can assign this responsibility, you still retain it. Authority can be delegated but responsibility cannot.

We have discussed the four principles of organization which govern the assignment of personnel to positions. No working situation is exactly like any other, and the proper way to handle each one depends on the special circumstances. As a supervisor, be open-minded and mission-oriented to accomplish a difficult task successfully.

Exercises (022):

1. By assigning 10 people to work for 1 team chief, what principle of organization have you violated?

2. Assigning three specialists to a technician for him to supervise but having them report to you is a violation of _____ .

3. A position that includes duties requiring unrelated skills at different skill levels is a violation of the principle of _____ _____

4. You assign SSgt Jones to train three apprentice specialists in metal bonding but require him to do it your way. What principle are you violating?

023. Point out important features of organizational and functional charts.

Organizational and Functional Charts. The most useful way to show your personnel where they stand und how they function as part of the organization is to display organizational and functional charts. The organizational/functional chart, illustrated in figure 2-1 has many uses. It:

a. Identifies lines of authority.
b. Lets the workers know what they are to do.
c. Establishes responsibility.
d. Indicates who reports to whom.
e. Shows who directs all or part of the work.
f. Gives others, such as inspectors, a clear idea of the organization.

When you prepare an organization/functional chart, keep the following terms in mind:

- Mission—A predetermined objective or goal.
- Function—A major area of work within the mission.

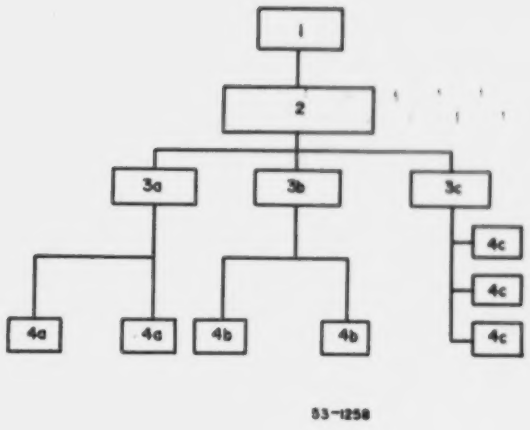

Figure 2-1. Organization chart layout.

• Operation—A major area of work within a function.

With these considerations in mind you are ready to plan your charts. You must follow the six basic rules for chart construction. These rules apply to both organizational and functional charts:

a. Plot one level above and two levels below the position being charted.

b. Use straight vertical and horizontal lines to connect the position blocks.

c. Make the position you are charting the largest block. The block above it and the block below it are a size smaller. The blocks at two levels below are a size smaller than the blocks at one level below.

d. All blocks on the same horizontal level should be of equal size.

e. Lines should enter any block at the top center or at the center of the left and leave any block at the bottom center.

f. Staff position blocks should be under the line position they are subordinate to. If there is only one staff position, plot it on the right side of the chart. If there are two positions, plot one on the right side and one on the left.

In the preparation of organizational and functional charts, there are management engineering teams and offices on most bases where assistance can be obtained.

Exercises (023):

1. How many levels are shown on an organizational or functional chart?

2. What errors, if any, are committed in figure 2-2?

024. List the factors to consider in work assignment and select the proper person to complete a specified task.

Work Assignment Factors. As with all supervision, there are factors that govern decisions in work assignment. Three important factors are skill level and experience, job priority, and work distribution.

Skill level and experience. If you know the skill level and experience of your worker, you can assign work that will be a challenge to him. If his work is a challenge, it will keep him "on his toes" and make him want to complete it. If his job is a bore, he may become unsafe and unhappy, creating problems in morale and discipline.

Job priority. Of course, the priority of a job affects your assignment of it. If the completion of the job is very important to the mission, you must assign your best specialist for its quick completion. However, for a lower priority job. you may be able to assign a less-experienced worker to broaden his experience and knowledge. Broadening a worker's experience benefits him, the Air Firce, and the supervisor.

Work Distribution. Work distribution is another important factor, blending the two factors just discussed. The workload must be divided equally. You must not show favoritism by assigning the better or cleaner jobs to specific individuals. Distribute the jobs evenly among the specialists who have the same skill levels. Failure to distribute work evenly and fairly causes hard feelings and unhappy workers.

Exercises (024):

1. What are the basic factors to consider in work assignment?

2. You have two equally qualified specialists working for you, Ed and Pete. You receive a work request to complete a very complicated job, which has a low priority. Pete has had experience at this type of job, but Ed hasn't. Whom should you assign the job to? Why?

025. Define the term "performance standards," and cite factors considered when developing performance standards.

Performance Standards. Just as you have a right to know exactly what your supervisor expects from you, so do your workers have that right. You also believe that you should be told how your work will be judged. Those whom you supervise are no different;

they, too, want to know how you will judge their performance. Both you and your subordinates are seeking "performance requirements." When performance requirements have been established for a task, it is followed by the performance standards that have been determined as acceptable for the task. Performance standards often supply information not given in the specialty training standard, such as quantity of results in a given time, quality of results in terms of how well the job must be performed, and manner of performance. Actually, a performance standard is a fancy term for what constitutes a satisfactory job.

Procedures for Developing Performance Standards. As the supervisor, you must set up performance standards for any jobs that do not already have them. Your determination of performance standards must be realistic and practical. Frequently, the supervisor has difficulty in setting standards because he overemphasizes the operating details of the job rather than the results it must achieve. By setting the standards at a reasonable level, you stimulate your people to work. They are neither overloaded nor underloaded. You put within their reach, through a safe workload, the satisfaction of a job well done. You have probably seen what happens when workers are overloaded. There are accidents, errors, fatigue, resentment, and slowdown. The situation is also bad when workers do not have enough to do. The results are usually mischief, excessive cost of operation, and grievance. Remember the problems of overloading and underloading when you are determining performance standards.

The performance standards for each work operation must describe acceptable performance. They should be set at a level of performance that can be fairly expected of any qualified, competent worker. It is generally true that workers become frustrated and quit trying to reach a goal if it is set too high. The standards must be set at a level attainable by the average worker with room for the exceptional worker to perform above the standard.

In this respect, you can readily see the dangers of basing the performance standards upon the level attained by the worker now assigned to the position. This assumes that he is meeting all the requirements of the position acceptably. If the position is filled by a person of unusually high qualification, it penalizes him by rating performance as unsatisfactory or unacceptable. If the present worker's performance is actually inadequate but is used as the only basis for writing performance standards, the level of satisfactory performance will be too low.

Another factor considered in writing performance standards is the fact that all workers do not produce exactly the same amount and quality of work. Rather, there should be a realistic range of performance that is considered acceptable. Performance below this range of performance that is considered acceptable. Performance below this range is below average and unacceptable. Performance exceeding this range is above average and outstanding.

Procedures for Developing Performance Requirements. Each supervisor must make certain that the worker understands fully what is expected in his job. The following procedures can be used for determining performance requirements:

a. Select the task or major work factors of the job.

b. Decide tentatively what is reasonable to expect as to:

(1) Quantity of results in a given time.

(2) Quality of results in terms of how well the job must be performed (margin for error).

(3) Manner of performance.

Discuss the tentative requirements with and secure agreement from:

(1) Workers assigned to the job.

(2) Your supervisors.

(3) Other supervisors determining requirements for the same type of operation.

d. Check for the possible effect of your tentative requirements:

(1) Trade or craft requirements.

(2) Management data.

(3) Requirements of higher echelons.

e. Review and formulate firm requirements and reach full understanding by workers affected.

Exercises (025):

1. What is meant by the term "performance standard?"

2. Why does the worker need performance standards?

3. What is a frequent difficulty encountered in setting up performance standards?

4. Performance standards must be _____ and _____ .

5. What is done to compensate for the fact that all workers do not produce the same amount or quality of work?

6. What factors are considered when determining what is a reasonable output of a worker?

026. Cite three factors to consider in worker evaluation, some of the advantages of using performance requirements, and the way to clarify your attitude in the evaluation process.

Performance Requirements. Just as with all of the other tools of management, performance requirements to be of any benefit must be used. The supervisor must weigh the worker's performance continually against the requirements and discuss it with the worker periodically. The supervisor must recognize the workers who have exceeded the requirements, help the workers who have failed to meet the requirements by training or other appropriate means, and motivate workers who are doing acceptable work to perform better if they are capable.

There are a number of distinct benefits that the supervisor can realize from the proper development and use of performance requirements. They can aid production by establishing minimum acceptable production goals for each worker. The supervisor benefits because of a better attitude on the part of the workers toward the work situation since they know what and how much is expected of them. Performance requirements provide a sound basis for estimating future work capacity; for planning, organizing, and assigning work; for determining who needs additional training and how much is needed; and for preparing personnel actions and formal ratings. In the formal evaluation of worker performance, which is an important duty of the supervisor, other factors must also be considered: the working conditions and the supervisor's attitude.

Working Conditions. When you are evaluating a subordinate's performance, take a careful look at the conditions of his work. Some of the questions you must ask yourself are: "Did these people have the correct tools and equipment to work with?" "Did they have enough time?" "What were the overall working conditions, such as weather and the state of the work area?" Only when you look at the overall picture can you properly evaluate your subordinates' work performance.

Attitude of the Supervisor. To determine your own part in the evaluation process, you must ask yourself two more important questions: "Did I supervise properly?" and "Are my personal feelings affecting my evaluation?" If you fail to carry out your supervisory duties, your failure will be reflected in your workers' performance. Never charge your mistakes to someone else. Your evaluations should be objective and impersonal. If you let your personal feelings affect your evaluations, you are not a good supervisor.

Exercises (026):

1. List three factors to consider in evaluating work performance.
2. List at least five benefits you can realize in the proper use of performance requirement.
3. What two questions can clarify your attitude toward your subordinates?

027. State the purpose of the suggestion program and list ways to initiate changes in the use of personnel and equipment.

In the course of your evaluations, you may find a better way of doing things. There are a number of ways to go about having new ideas evaluated. Examples of three possible ways are described below.

Suggestion Program. If you know a better way of doing something, you should try to get that way adopted. The Air Force is always looking for improved methods, safer, cheaper, and faster. Figure 2-3 illustrates a suggested improvement. This improvement is for the safety of pedestrians and is submitted on an AF Form 1000, Suggestion, as all suggestions should be. A suggestion does not have to be work-related, as we have illustrated.

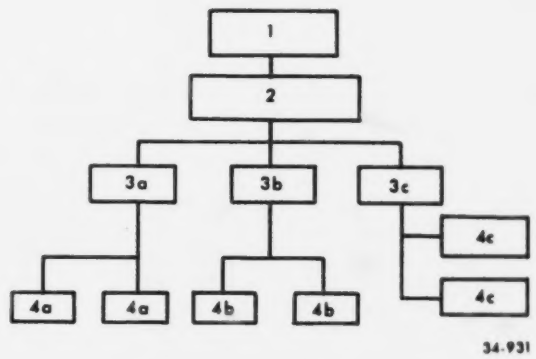

Figure 2-2. Objective 023, exercise 2.

If your suggestion to save time or material is adopted, you can share in the savings. The Air Force will pay a suggestor part of the overall savings if his suggestion is adopted. Obviously, all suggestions will not save money, but don't let a lack of monetary value stop you from submitting a suggestion. Safety suggestions, such as the one in figure 2-3, will not save money but may save a life. Worthwhile suggestions such as this one are appreciated and receive recognition.

AF Form 1000 is self-explanatory, and you can complete it very easily. Your name doesn't even have to be

HOW TO MAKE YOUR SUGGESTION

DISCUSS: Discussion with your supervisor is encouraged.
COMPLETE: Complete all blank spaces in Sections I and II, except "Suggestion No." in Section III enter "Subject Of Suggestion" and your name and mailing address.
SIGN: Be sure to sign your suggestion in Section I.
ADD: Use additional sheets for drawings or pictures when necessary. Attach separate sheet for co-suggester's Personal Data Information.
SUBMIT: Suggestion may be submitted through your supervisor, placed in a suggestion box, or mailed to the Suggestion Committee.

IMPORTANT! SUBMIT ALL SECTIONS OF THIS FORM—DO NOT DETACH ANY SECTION.

I. SUGGESTER'S PERSONAL DATA

NAME OF SUGGESTER (Last, First, Middle Initial) (Include Serial Number, if Military)	HOME OR MAILING ADDRESS (Include ZIP Code)	SUGGESTION NO.
RICHARD, JOESPH D. H. FR 030-38-7164	244 LILAC, RANTOUL ILL. 61866	

MR. / MISS / MRS. / MSG.	GRADE	SOCIAL SECURITY NUMBER	(If different from above, legal address for tax purposes)
MRS. X MSG.	SSGT	030-38-7164	(SAME)

INSTALLATION, ORGANIZATION AND/OR SYMBOL	POSITION TITLE (Add AFSC, if military)	OFFICE PHONE
3349th INSTRUCTOR SQ./TWSTC/CHANUTE	TECHNICAL WRITER T53270	2545/3419

SUBJECT OF SUGGESTION: SAFETY OF PEDESTRIANS

I HEREBY AGREE THAT, UPON ACCEPTANCE OF A CASH AWARD(S), THE USE OF THIS SUGGESTION BY THE UNITED STATES SHALL NOT FORM THE BASIS OF A FURTHER CLAIM OF ANY NATURE UPON THE UNITED STATES BY ME, MY HEIRS, OR ASSIGNS.

DATE	SIGNATURE OF SUGGESTER	MAY YOUR NAME BE USED DURING THE PROCESSING OF THIS SUGGESTION?
17 Oct 74		☒ YES ☐ NO (If "No", do not complete first line in Section II.)

II. SUGGESTION

AWARDS COMMITTEE WILL DETACH THIS PORTION BEFORE FORWARDING FOR EVALUATION

NAME OF SUGGESTER (Mr., Mrs., Miss, Military Grade)	ORGANIZATION AND/OR SYMBOL	OFFICE PHONE
SSGT. JOESPH D.H. RICHARD	3349th INSTRUCTOR SQ. TWSTC	2545/3419

I BELIEVE THIS SUGGESTION WILL: ☐ SAVE TIME ☐ SAVE MATERIAL ☐ IMPROVE METHODS ☒ IMPROVE SAFETY ☐ SIMPLIFY WORK — OTHER (Specify) — SUGGESTION NO.

DESCRIBE SUGGESTION COMPLETELY. TELL WHAT THE PRESENT PRACTICE IS, CHANGE THAT IS SUGGESTED, WHERE (Indicate OPR) AND HOW CAN IT BE USED, AND BENEFITS TO BE DERIVED FROM ITS USE. (If suggestion is hand-written, please use black pencil or black ink, if possible.)

I FEEL THERE IS INSUFFICIENT LIGHTING ON ENTRANCE DRIVE BETWEEN A STREET AND M STREET FOR THE AMOUNT OF PEDESTRIAN TRAFFIC IN THIS AREA AT NIGHT. THERE ARE CURRENTLY SEVEN CROSS WALK AREAS AND ONLY FIVE STREET LIGHTS. THIS CREATES A HAZARD FOR MOTOR VEHICLE OPERATORS IN SEEING THE PEDESTRIAN WHILE DRIVING WITH LOW BEAM HEADLIGHTS, THIS IS TRUE EVEN AT 15MPH BECAUSE OF THE PEDESTRIANS DARK COLORED CLOTHES DURING THESE WINTER MONTHS. I SUGGEST ONE STREET LIGHT BE PLACED AT EACH CROSS WALK.

(Continue on Reverse)

AF FORM MAR 66 1000 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

III. SUGGESTION ACKNOWLEDGEMENT

SUBJECT OF SUGGESTION	SUGGESTION NO.

THANK YOU FOR YOUR SUGGESTION. IT HAS BEEN ASSIGNED THE ABOVE SUGGESTION NUMBER. CAREFUL CONSIDERATION WILL BE GIVEN YOUR SUGGESTION, AND YOU WILL BE INFORMED WHEN ACTION IS TAKEN. YOUR INTEREST IN PRESENTING THIS IDEA IS APPRECIATED. (Use above number in checking status of your suggestion.)

DATE	EXECUTIVE SECRETARY, AWARDS COMMITTEE

TO:

IMPORTANT!
Please print your name and mailing address (home or office) in the space provided at left, keeping within the printed corner marks. If home address is given, include ZIP Code.

Figure 2-3. AF Form 1000.

involved if you check the "NO" block section in I. Fill in Sections I and II as explained on the form. Section III will be returned to you when your suggestion is received at the base suggestion office.

The Air Force Suggestion Program is only one way to initiate changes. Another way is through the chain of command.

Chain of Command. You may feel you have an idea that can improve shop practices and want to adopt it. The chain of command method begins with your supervisor. You discuss your idea with him. It may end there, or you and he may go to see his supervisor. You may talk to everyone, all the way up to the commander, and either your idea will be used or you will know why it can't be.

Complaint Program. Another way to change things is through the complaint program. Every squadron has a complaints NCO and a complaints officer. If you don't like the way something is done, this program gives you an opportunity to do something about it. You discuss the problem with the complaints NCO or officer and obtain his help in correcting the situation.

Exercises (027):

1. State the purpose of the Air Force Suggestion Program.

2. Give three methods of initiating changes.

3. The Air Force will pay you for which change method?

2-2. Training

You already know about on-the-job training because you have been a trainee for some time. You have completed the 3-skill-level requirements and are now training for the 5 skill level. You should be ready to transfer from trainee to trainer. This section will help you become a trainer as we discuss selecting and recommending personnel for training, planning and conducting OJT programs, and maintaining training records.

028. Define "training needs" and point out important features of training needs and trainee selection.

Determining Training Needs. If every trainee had the same degree of skill and the same qualifications, determining the training needs would be simple. However, no two airmen have exactly the same skill, ability, attitude, and application, and the job of finding out just what each one needs to learn to perform better is somewhat complex.

We cannot simplify the process by giving everyone the same training. This would be very costly, since many would receive unnecessary training, the trainer would waste valuable time needed for other duties, and the time of the trainee would also be wasted in training he doesn't need. What is more boring than going through a training program a second or third time? Finally, not all trainees have the same ability to learn. The problem facing you is to find out the needs of each individual so that your training program can be patterned to meet those individual needs.

The problem has two parts. The first part is determining what needs to be done. The second part of the problem is determining what the trainee is capable of doing. These two parts combine in the solution of the problem. The difference between what the trainee can do and what he must do represents his training needs. When you know the training needs for each trainee, you know the training needs of the whole shop.

To solve the first part of the problem—to determine what has to be done—you must know what duties are involved in your mission. Explore each operation and examine the job qualification requirements. You can get information on work to be done from the specialty description, specialty training standard (STS), and performance requirements.

To solve the second part of the problem, there are many ways to find out how much the trainee can already do. Usually, his records show his background, training, and experience. You can have the trainee show his skills by actual performance. Observing the trainee's methods and work habits on the job may reveal to you a need for additional training. Compare the trainee's performance with the performance requirements of the job.

With the collection of this data, you can plan your training program. You know what operations must be stressed. You know what is important and what is not important. Now, you are ready to administer the training.

Exercises (028):

1. Define the term "training needs."

2. What problems would occur if all trainees received the same training?

3. How does a trainer determine what needs to be taught?

4. What factors affect the amount of training a trainee receives?

029. Define the term "OJT" and point out important features of the OJT program.

OJT Program. On-the-job training (OJT) is a planned training program designed to qualify airmen, through self-study and supervised instruction, to perform in a given Air Force specialty (AFS). This is done while the trainee is actually working in a duty assignment of the AFS. OJT is conducted in the actual work situation by designated personnel within the unit who are working in support of the unit mission. Even though the responsibility for conducting on-the-job training is delegated to specific individuals within the unit, the overall OJT program is, and must be, of concern to every person assigned to the unit. The nature and effectiveness of the training conducted in the unit today largely determines the quality of the work produced by the unit tomorrow.

Before you can plan and conduct an OJT program effectively, there are some areas you should become familiar with. They are: AFM 50-23, *On-the-Job Training,* the dual-channel OJT concept, duties and responsibilities for OJT, and conducting OJT.

AFM 50-23. This manual, *On-the-Job Training,* has been prepared for the Air Force personnel who plan, administer, supervise, and conduct OJT programs. It contains detailed information and references that concern on-the-job training. Subject matter areas covered in the manual include:

- The dual-channel OJT concept.
- Controls for OJT.
- Duties and responsibilities for OJT.
- Administration of OJT programs.
- How to administer the CDC.
- References concerning OJT.
- Sample evaluation checklists.
- Sample forms used in OJT.

Dual-Channel OJT Concept. The dual-channel OJT concept is based on the premise that there is, in career development, certain knowledge that the airman must acquire. This is necessary if you are going to progress in your career field and have the ability to move quickly from one kind of equipment or system to another. The trainee acquires specialty knowledge by enrolling in and studying career development courses, and acquires job proficiency while performing on the job under the supervision of a skilled worker.

Career development. Career development courses contain the fundamental knowledge required for OJT upgrade training. These courses are programmed and developed by Air Training Command, which forwards the material to Air University. The Extension Course Institute (ECI) of Air University publishes and administers the career development courses. ECI develops and publishes standard procedures for the administration of CDCs, information regarding the activation of CDCs, enrollment criteria, and special instructions. ECI also evaluates student progress in the courses and administers the course examination (CE). After its successful completion, the student is awarded a certificate.

Job proficiency. The entire OJT program hinges upon the learn-by-doing and self-study concepts. Job proficiency training is normally conducted within the unit to which the trainees are assigned for duty. The responsibility for conducting the job proficiency phase of OJT is a part of the job of each person who supervises the work of airmen.

Job proficiency training implies practical application. It places the trainee in an operational situation where he is assigned certain specific tasks that are part of his duty assignment. As the trainee acquires skill in the simpler tasks, he is assigned others that are progressively more complex. In this way, the trainee constantly broadens his skill knowledge until he finally can perform all elements of the job. Meanwhile, the organization benefits from the worker's productiveness while he is learning.

The proficiency of the trainee is recorded on a Job Proficiency Guide (JPG). This JPG is an annotated specialty training standard (STS), which is a list of all the tasks performed in a specialty. The specific tasks in the trainee's assignment are circled in the STS. The trainer certifies each task when the trainee is proficient in it to the required level.

Exercises (029):

1. Who has the responsibility for conducting the overall OJT program?

2. In what ways is AFM 50-23 used for conducting the OJT program?

3. What type of training is received from each channel of the dual-channel OJT concept?

4. How is a STS used when conducting OJT?

030. Given a list of OJT duties, identify the individual who is responsible for each.

Duties and Responsibilities for OJT. A sound OJT program is a military necessity with practical, measurable returns. It is an integral part of the primary mission of every organization to which airmen are assigned. It must have the full support of all concerned if it is to achieve its purpose. Every individual from commander to trainee must accept and enthusiastically discharge his or her OJT responsibilities. By keeping this in mind we will realize the fullest potential of our most valuable resource—our assigned personnel. Although commanders, personnel officers, training administrators, and supervisors at all levels are responsible for portions of the OJT program, we are limiting the coverage in this section to personnel closer to the metals processing shop. We will discuss the responsibilities of the squadron OJT supervisor, the shop supervisor, the trainer, and the trainee.

Squadron OJT supervisor. In your squadron, the OJT supervisor may be called by another title, such as squadron training NCO or unit training supervisor. His duties will be somewhat like the following:

a. Teach the officer in charge, the shop supervisor, and the trainers the concepts, scope, and objectives of OJT.

b. Provide shop supervisors with all directives pertinent to their OJT programs.

c. Obtain training literature for the shop supervisors.

d. Brief the shop supervisors on the use of CDCs.

e. Assist the shop supervisors in selecting trainers.

f. Counsel shop supervisors about trainer-trainee working relationships and methods of training on the job.

g. Counsel shop supervisors on the necessity for trainee motivation while participating in CDCs.

h. Maintain, as required, a squadron OJT progress chart.

i. Start on-the-job training records and deliver them to the appropriate shop supervisors.

j. Continuously supervise actual training.

k. Advise the squadron commander and the servicing personnel office OJT unit about the status of the program and recommend improvement.

l. Evaluate the accomplishments of each section.

m. Insure that training records provide a complete and accurate record of each airman's consolidated training effort.

n. Monitor requests for classification actions that result from training.

o. Check the preparation of appropriate orders, AF Form 2095, Assignment/Personnel Action, and personnel standard UAR (uniform airman record) data transactions, to make sure that entries pertaining to OJT accurately reflect the trainee's status.

p. Make certain that address and zip code/shred of test offices are submitted to ECI for incoming personnel enrolled in CDC course(s).

q. Make certain that reassigned trainees leave the organizations with all uncompleted CDC materials and related answer sheets.

r. Receive and distribute ECI materials for personnel enrolled in CDCs.

Shop supervisor. Responsibility for conducting OJT is inherent in the position of a shop supervisor. Since he daily contacts all personnel assigned to his unit, he occupies a key position in the OJT program. In some units, the supervisor is also the trainer. Since you are in training for the 5 skill level, you will be performing some of the OJT duties which are normally performed by the shop supervisor. The following list contains some of the OJT duties of the shop supervisor:

a. Select the best qualified trainers within the shop.

b. Instruct trainers and trainees in the objectives of the OJT program.

c. Determine the proficiency training required for each individual airman to progress in his AFS.

d. Determine the number of trainees who can be effectively trained by each trainer.

e. Insure that trainers enroll in appropriate CDCs and monitor their progression.

f. Assist trainers in using pertinent directives, developing individual job breakdowns, and conducting OJT.

g. Motivate personnel associated with the program through daily supervision.

h. Provide guidance in methods of training and testing, in personal relations, and in good management principles.

i. Determine the requirement for group training to provide background information and theory.

j. Evaluate the progress of each trainee in job proficiency and job knowledge.

k. Maintain the AF Form 623 On-the-Job Training Record, for each airman.

l. Certify that trainees have completed OJT and/or job proficiency development requirements listed in STSs and JPGs.

m. Start OJT status requests for airmen (entry into, completion of, and withdrawal from).

n. Evaluate and report the effectiveness of the OJT program.

OJT trainer. Ideally, the OJT trainer is the trainee's immediate supervisor. However, for various reasons, this situation may be difficult to arrange in some organizations. As a result, shop personnel other than the supervisor may be appointed to train individuals or small groups of trainees. Trainers should have technical know-how, as well as the ability to get along with people and inspire the confidence of the trainees. Trainers should not be assigned to full-time instructional duty. Rather, they are skilled individuals who are assigned to production jobs with trainees as assistants. In the airframe repair shop, you can expect to perform OJT trainer assignments, such as those described in the following list:

a. Prepare detailed job breakdown and/or JPGs as

necessary, indicating the important steps involved in the job.

b. Instruct trainees on the actual operating equipment.

c. Develop and conduct oral, written, or performance tests to evaluate job proficiency development.

d. Motivate the assigned trainees.

OJT trainee. The trainee must understand the need, the objectives, and the procedures of OJT, as well as his own responsibility to accept and perform training assignments to the best of his ability. The trainee should understand that Air Force policy places him responsible for attaining and maintaining qualifications in his specialty. Facilities for self-improvement, such as off-duty education, ECI courses, technical training, career development courses, and self-study guides are available or can be made available. Each individual is encouraged to use every opportunity to improve his technical qualifications and his professional and military knowledge.

In the airframe repair shop, your present OJT status is that of a trainee for the 5 skill level, which puts you in the dual role of trainee and trainer. At this time you are still a trainee but are learning how to be a trainer and how to perform the OJT duties of the shop supervisor. The following list contains only a few of the broad responsibilities you have as a trainee:

a. Understand your AFS description, the training requirements of your STS and JPG, and the contents of your training folder.

b. Accept and react favorably to the motivational efforts of your OJT trainers and supervisors.

c. Understand, accept, and perform all of the training requirements and assignments in an efficient manner.

d. Budget your available time (on- and off-duty) so that you can complete your own CDC and local study assignments within the time limits.

e. Maintain all issued training materials in good condition.

f. Pick up CDC materials and answer sheets from your trainer and supervisor when you are reassigned to another unit. Deliver such materials intact to the supervisor at your new unit.

Exercises (030):

Identify the individual responsible for each of the following duties by placing the letter from column B in front of the number in column A:

Column A	*Column B*
_____ 1. Develop and conduct performance tests.	a. Squadron OJT
_____ 2. Maintain an OJT progress chart.	b. Shop supervisor.
_____ 3. Receive ECI materials for individuals enrolled in CDCs.	c. OJT trainer.
_____ 4. Select OJT trainers.	d. OJT trainee.
_____ 5. Complete the CDC within time limits.	
_____ 6. Prepare job breakdowns.	
_____ 7. Determine the need for group training.	
_____ 8. Maintain training materials in good condition.	

031. Match terms concerning procedures used to conduct OJT with their definitions or phrases that best describe them.

In some ways, instructing is different from other work. You either like it or you do not like it. If you do not like to instruct, you probably do not do it well. Since teaching is an essential part of the supervisor's and trainer's job, the person who cannot instruct successfully is not a good supervisor.

There is, though, a brighter side to the picture. Teaching is a skill and can be learned. When you have learned and used tested principles, methods, and techniques, you will find that teaching can be one of the most interesting parts of your job. Good instruction produces two very desirable results. First, your trainees are competent and capable of doing a good job. Second, you have the personal satisfaction of knowing that through your efforts each trainee has become a productive worker.

Training Principles. Certain basic and easily understood principles apply to all training situations. Supervisors should conduct local training programs to qualify OJT trainers in these basic principles. Trainers should understand and apply the following principles to help them improve their skill in instructing:

a. Go from the easy to the difficult. Always begin with simple parts of a job. Knowing how to perform parts of the job after a short practice gives the trainee confidence and inspires him to learn the whole job.

b. Go from the known to the unknown. Find out what the trainee already knows about the subject and start from there. Relate the new material to what he already knows. Give a complete and friendly briefing on the overall program and where the trainee fits into it.

c. Emphasize accuracy and understanding rather than speed while the trainee is learning.

d. Emphasize safety at all times.

e. Clearly define the limits of the training objective and let the trainee know what is expected of him.

f. Present new material in short units, ones that can be finished in one training session. Short, related training units are not so likely to be confusing.

g. Be sure that the trainee sees the job as a whole. Fit all the short steps into the whole operation or objective.

h. Always remember that the trainee learns by doing. Put him to work as soon as he understands what he is to do. Give him plenty of practice.

i. Allow the trainee to develop by himself. The trainee does the learning; you guide and help. Be careful not to dominate, but do not relax your supervision to the extent that the trainee may harm himself or damage equipment.

j. Any training procedure must make sense to the trainee. If it doesn't change or discard it.

k. Recognize the trainee's work. Let him know how he is doing.

l. Never try to bluff. Never resort to sarcasm or ridicule.

Training Methods. Your trainer responsibilities are in addition to your other duties, because the OJT trainer function is not considered a full-time duty. Obviously, as an OJT trainer, you are neither required nor expected to become a professionally qualified educator. But you are expected to use certain training methods and techniques that are known to be effective. (This requirement and responsibility is contained in the specialty description for AFSC 53153.) It follows that, when you are selected as a trainer, you must learn to perform efficiently, using those methods that make an OJT program effective. Job instruction generally involves four methods of imparting new knowledge or manual skills.

Lecture. The lecture method is useful for informing trainees. Its effectiveness is increased, however, when it is combined with one or more of the other instructional methods. When the training objective is the development of new skills, the lecture of "telling" method alone has limited value.

Discussion. Discussion is a valuable training method because it promotes a two-way exchange of ideas during group instruction, for example, to provide background information of common interest to the entire group. Questioning is very useful, when you are employing this method, to inform the trainee as well as to check his grasp of the instruction. To help the trainee think through the logical steps of a new task, phrase your questions so that they cannot be answered with a straight "Yes" or "No." Use questions that begin with such words as "What," "Who," "Where," "When," "Why," and "How." Questioning and discussion can be used effectively with all other instructional methods.

Demonstration. Demonstration or "showing" is most valuable when the training objective is the development of new manual skills. It is particularly useful if you are presenting the various steps of a very long operation that must be performed without stopping. The trainee is taught a part of a job, with the trainer doing the rest. After learning one step of the total job, the trainee learns a second step, with the trainer again completing the operation. In this way, the trainee learns the whole job by small increments. The effectiveness of the demonstration method is increased when it is combined with the discussion method.

Performance. Performance is by far the most effective method in OJT. A trainee truly learns by doing under the careful eye of the trainer while performing in a productive capacity. It follows that an OJT airman should immediately be given a simple job to do, such as cleaning a piece of metal to be bonded. It is most practical to assign the airman to assist others who are producing. After an airman has received training on some particular task until he is able to do it with the desired proficiency, he should be rotated to another task. With a progressive rotation plan, the trainee grows in skill and knowledge until he can perform all the tasks of the duty position.

Training Techniques. Supervisors must be sure that trainers use training techniques that achieve good results. The five steps discussed in the following text have been used by many trainers to develop techniques of their own.

a. Prepare the training situation.

(1) Be sure that the tools and equipment are on hand and are in good working order.

(2) See that the shop or room is available and that it is properly heated, lighted, and ventilated.

(3) See that the training aids planned for use are available and in good working order.

b. Prepare the trainee to receive job instruction.

(1) Put the trainee at ease. Help him to build confidence. Your training efforts are likely to be in vain if the trainee is nervous or ill at ease.

(2) Find out what the trainee already knows about the job. Do not waste time on things he already knows. Start where his knowledge ends.

(3) Gain his interest. Explain the job or operation at hand and relate that job to the work of the whole unit. This helps the trainee realize the importance of the job.

(4) In demonstrating a job, make sure that the trainee observes from the proper position. Do not have him look at the job backwards or from an angle other than the one from which he will work.

c. Present the operation to the trainee.

(1) Tell, show, illustrate, and question. Then, when the trainee understands, have him do the job.

(2) Give only a few instructions at one time. He will learn more quickly if you present new ideas gradually.

(3) Make the key points clear. These make or break the operation. To a large extent, they determine the ultimate success or failure of the training.

(4) Use available training aids when they help to put the point across. Do not use them just to fill in time. Before using any training aid, be sure that it applies directly to the subject and that it works.

(5) Be patient; remember that haste makes waste. Work for accuracy first, speed later.

(6) Repeat the job and explanation, if necessary.

d. Let the learner perform.

(1) Have the trainee do the job under observation. Then have the trainee do it again and explain what he is doing and why. The trainee must understand what he is doing.

(2) Have the trainee explain the key points. Correct his errors, but do not correct them in a way that will make the trainee feel that you are not satisfied with his progress.

(3) Continue to have the trainee perform and explain until you know that he knows.

e. Follow up.

(1) Put the trainee on his own to get the feel of the job by doing it himself. Tell him to whom to go for help and make sure that the designated person understands his responsibility.

(2) Check the trainee's work frequently—perhaps every few minutes at the start; then every few hours. Be on the lookout for incorrect or unnecessary moves, but do not make an issue of them. Expect a few mistakes; if there are none, congratulate the trainee for a job well done.

(3) Get the trainee to look for key points as he progresses. Taper off the coaching until he is able to work under normal supervision.

(4) Be sure that the trainee is observing the approved safety practices.

Exercises (031):
Match each item given in column B with the statement in column A that is most appropriate for that item. Some items may be used more than once.

Column A	*Column B*
____ 1. Going from the known to the unknown.	a. Lecture.
____ 2. Most useful method for informing trainees.	b. Discussion.
____ 3. Most useful method for teaching manual skills.	c. Demonstration.
____ 4. Least effective method of teaching.	d. Performance.
____ 5. Most effective method of teaching.	e. Training principles.
____ 6. Go from the easy to the difficult.	f. Training techniques.
____ 7. Method of teaching usually combined with other methods to be effective.	
____ 8. Gain trainee's interest.	
____ 9. Emphasize safety at all time.	
____ 10. Trainee is taught individual steps of an operation.	
____ 11. Trainee learns by doing.	
____ 12. Involves telling about a new skill.	
____ 13. Let the learner perform.	
____ 14. Emphasize accuracy rather than speed.	
____ 15. Method useful in checking on trainees' understanding.	

032. Given specific items for an On-the-Job Training Record, tell where they should be entered.

On-the-Job Training Record. Upgrade training, lateral training, and retraining conducted on the job are intended to end in the award of an AFSC. The requirements for a duty position of the specialty should agree with the requirements for the specialty as specified in the STS. Without some method for recording training at section level, individual units would duplicate training. This would be especially true when airmen transfer from one major command to another. AF Form 623, On-the-Job Training Record, is one of the methods used to achieve uniformity of training. This form contains a cumulative and consolidated account of an airman's knowledge and proficiency training. The form has six sections, which are individually identified by purpose. This permits the recording of all training achieved in job proficiency development, in career knowledge development, and in formal courses. The form is also used to record qualification training, which occurs after upgrading has taken place.

The AF Form 623 becomes an official and permanent part of each individual's training record. Since the AF Form 623 reflects the entire range of an airman's progression, it may become necessary to insert a continuation sheet (AF Form 623a) to show the progression picture over an extended period of time. Because the AF Form 623 must be readily available to the supervisor, it is normally kept in the immediate working unit, though it may be maintained in a centralized location. When an airman is transferred, his On-the-Job Training Record must accompany him to the gaining organization. The airman's training is expected to continue at his next assignment, unless he is specifically withdrawn by the gaining organization.

AF Form 623 Entries. Entries in the AF Form 623 are made with a typewriter, ink, or pencil, depending upon the entry. The form is completed as explained below.

Section I, Identification Data (fig. 2-4). On the front page of the form you must enter the trainee's last name, first name, middle initial, grade, social security number (SSAN), primary AFSC, duty AFSC, and training to AFSC, date entered training, and general AQE score. Enter the date for supervisor's evaluation, commander's evaluation, and maximum training dates only when the individual trainee enters upgrade training or retraining. In order to determine the date for supervisory evaluation, date for commander evaluation, and maximum training date, refer to AFM 50-23, *On-the-Job Training.* Also in this section, you must enter the estimated training completion date.

Section II, Orientation and Certification (fig. 2-4). When the immediate supervisor enters his name and grade in the appropriate block, it constitutes certification that the action listed opposite the block has been performed. The trainee signs in the appropriate block when he is entered into upgrade training. If the AF Form 623 is reaccomplished, the certifying official signs in the block titled, "Signature and Title of Certifying Official."

Section III, Reading Achievement Test (fig. 2-4). Consult AFM 50-23 to determine the necessity for this test and enter the results as applicable.

Section IV, ECI/CDC Participation, etc, (fig. 2-4). Enter all CDC, ECI, and other correspondence courses satisfactorily completed. In column A enter

SECTION I — IDENTIFICATION DATA

LAST NAME — FIRST NAME — MIDDLE INITIAL		PAFSC	DATE ENTERED TRAINING	GENERAL AQE SCORE	DATE FOR SUPERVISORY EVAL
ELAISON, GEORGE F. JR.		53133	1 Oct 75	80	27 Feb 76
GRADE	SSAN	DAFSC	ESTIMATED TNG COMP DATE		DATE FOR COMDR EVAL
AIC	022-43-2763	53153	1 APR 76		30 SEPT 76
		TNG TO AFSC			MAXIMUM TRAINING DATE
		53153			31 MAR 77

ON-THE-JOB TRAINING RECORD

SECTION II — ORIENTATION GUIDE AND CERTIFICATION RECORD

IMMEDIATE SUPERVISOR (GRADE AND NAME)	BRIEFS YOU ON SECTION TRAINING PROGRAM AND EXPLAINS THE FOLLOWING
TSgt. VALENTINE	a. YOUR AFS DESCRIPTION. AFM 39—1 b. TRAINING REQUIREMENTS. AFM 50—23 AND JPG c. UPGRADING AND PROMOTION. AFR 39—29 d. APPRENTICE KNOWLEDGE TEST (AKT) PROCEDURES. AFM 35—1 e. PROFICIENCY TRAINING. AFM 50—23 f. EXPLAINS USE OF AF FORM 623, STS AND JPG. AFM 50—23 g. CERTIFIES COMPLETION OF JPG TASK ITEMS. AFM 50—23
TRAINEE SIGNATURE George Elaison	I CERTIFY THAT THE ACTIONS LISTED ABOVE HAVE BEEN ACCOMPLISHED AND THAT I UNDERSTAND MY INDIVIDUAL RESPONSIBILITIES FOR CAREER PROGRESSION, AS ESTABLISHED IN AFM 50—23.
SIGNATURE AND TITLE OF CERTIFYING OFFICIAL	I CERTIFY THAT THIS AF FORM 623 IS A COPY OF PERTINENT DATA CONTAINED IN A PREVIOUS AF FORM 623.

AF FORM MAR 74 623

Figure 2-4. AF Form 623, (page 1).

SECTION III	READING ACHIEVEMENT TEST				
PART I (DATE AND SCORE)			PART II (DATE AND SCORE)		
SECTION IV	**ECI/CDC PARTICIPATION, ETC**				
A COURSE NUMBER & TITLE	B NUMBER OF VOLS	C DATE COMPL MONTH & YEAR	A COURSE NUMBER & TITLE	B NUMBER OF VOLS	C DATE COMPL MONTH & YEAR

SECTION V	TECHNICAL AND SUPERVISORY TRAINING		
COURSE NUMBER AND TITLE	DATE COMPL	COURSE NUMBER AND TITLE	DATE COMPL
3ABR53133, Basic Airframe Repair	31 Jul 75		

Figure 2-4. AF Form 623, (page 2).

SECTION VI	REMARKS (INCLUDE DATES)
15 August 1975, 30 days emergency leave granted - Father sick - TSgt. Valentine	

Figure 2-4. AF Form 623, (page 3).

the course number and title, in column B the total number of volumes in the course, and in column C the date on which the course was satisfactorily completed.

Section V, Technical and Supervisory Training (fig. 2-4). List all technical and supervisory courses satisfactorily completed. The usual entries are formal technical schools, but may include FTD courses, training management classes, NCO Leadership School, etc.

Section VI, Remakrs (fig. 2-4). Appropriate entries in this section include, but are not limited to:

a. Name, grade, date, and action taken as a result of evaluations required by AFM 50–23.

b. Dates of time periods and circumstances under which completion of training objective was delayed.

c. Appropriate information to indicate that the trainee is not enrolled in the required CDC and why.

Entry Restrictions. Entries in the AF Form 623 are restricted to permanent training entries only. Items of a temporary nature, such as required progress evaluation, and counseling, are entered in AF Form 623a.

Exercises (032):

State where the following entries should go in an airman's training record:

1. The date of a counseling session on the airman's progress.

2. The date the airman completed CDC 53153.

3. The airman's SSAN.

4. The name of the certifying official.

5. The completion of Management Course 74E.

6. The airman's score on the Reading Achievement Test.

7. The airman's general AQE score.

8. The number of volumes in CDC 53153.

033. Cite the key features of the USAF Graduate Evaluation Program in terms of its purpose, documentation, job performance evaluation, and the role of CDCs in the program.

USAF Graduate Evaluation. The Air Force spends considerable amounts of money and time to provide the best training possible. Equipment changes, new procedures, and needs of the AF require constant changes within the training courses. Supervisors, trainers, and trainees play a key role in keeping current courses up-to-date by providing "feedback" on training received. You furnish this feedback by taking an active part in the USAF Graduate Evaluation Program. Your evaluations, along with others, answer the question— "Is the training being conducted meeting the current needs?"

The evaluation may be conducted in any one of four manners: field evaluation visits, field evaluation questionnaires, CDC trainee questionnaires, and the job performance evaluations, each of which will be discussed.

Field evaluation visits. The personnel from the training activities are concerned with the graduates assigned to the unit within 6 months immediately prior to the visit. Evaluation data are obtained by actual discussions with the graduate, the immediate supervisor, and others having knowledge of the graduate's performance. The applicable training standard is used as the reference to evaluate the graduate's frequency of use and his ability to perform the tasks for which trained.

Direct correspondence questionnaire. The questionnaires for formal course graduates are sent to recent graduates and their supervisors. They are mailed by the training activities to graduate-receiving units within 6 months after graduation (within 24 months for personnel not on extended active duty and who are assigned to USAFR and ANG units). The questions asked pertain to graduate qualification in terms of the skills and proficiency levels reflected in the approved training standard.

Career Development Course (CDC) Trainee Questionnaire (AF Form 1327). The CDC Trainee Questionnaire is completed by a sampling of the CDC enrollees when they take course examinations. The CDC testing officials collect the forms and mail them to ATC training centers within 1 week of administration of the test.

At the training centers, the AF Forms 1327 are analyzed much the same as the formal course graduate direct correspondence questionnaires, and the results are the same. If responses to AF Form 1327 identify problem areas in the CDC, the training activities will

conduct followup evaluation projects to determine the actions required to resolve them.

There appears to be some apprehension in field-level units that CDCs do not contain specific equipment maintenance-related job procedures. This is in full accord with the AF dual-channel OJT concept. Career development courses are designed to provide the learning material. OJT utilizes these knowledges while allowing the individual to be a productive member of the AF team and/or learn more advanced or new skills or develop higher proficiency levels on those skills previously acquired. Every individual working on the job should realize that he has a responsibility to train lower-level personnel and increase their productivity in AF-assigned job tasks.

Job performance evaluations. Such evaluations may be conducted if the required training evaluation cannot be obtained by other less-costly methods.

This device is for use by supervisors throughout all commands. The immediate supervisor must prepare such a report if:

a. The supervisor observes that a graduate from a technical training course does not meet the proficiency level specified for a task or knowledge listed in the approved specialty training standard (STS). To be objective, the supervisor must consider the elapsed time between graduation and operational performance as well as any difference between training equipment and operational equipment.

b. The graduate is not required to perform tasks listed in the STS while working in the assigned AFSC.

c. The STS code levels or tasks exceed the requirement of the graduate's AFSC.

Exercises (033):

1. What is the purpose of the USAF Graduate Evaluation Program?

2. What document is a measurement tool in evaluating training?

3. When are job performance evaluations accomplished?

4. Why doesn't a CDC contain specific equipment maintenance job procedures?

5. How is data obtained during field evaluation visits?

6. What type of information is asked for in direct correspondence questionnaire?

7. What is the purpose of CDC trainee questionnaires?

Supply System

YOUR DEALINGS with supply up to this point in your career have been very limited. As you advance in experience and responsibilities, so will your involvement with the supply system. This chapter is designed to provide you with the basic knowledge of the various aspects of the AF supply systems that are used in the day-to-day operation of the airframe repair shop.

3-1. Fundamentals of Supply Procedures

The Air Force does not own property. The equipment issued to the airframe repair shop and the toolbox issued to you are not owned by the Air Force. They are public property controlled by the Air Force. Supply discipline is concerned with property accountability and responsibility in the Air Force supply system.

Let's look at what the supply system is, why we have the system, and how it operates.

034. State the purpose and indicate functions of the Air Force supply system.

Purpose and Function of the Supply System. Briefly stated, the purpose of the Air Force supply system is to insure that the necessary supplies and equipment are available for the AF to meet its mission requirement. The Air Force supply system, as are in all other military services, is based on the Federal Classification Cataloging System. The AF has developed its own policies, procedures, and manuals in using the Federal supply system.

Air Force Manual 67-1, *USAF Supply Manual,* establishes a uniform system of supply control throughout the USAF. It prescribes standardized procedures for the requisition, purchase, receipt, storage, stock control, issue, shipment, disposition, identification of, and accounting for AF supplies. From the overview of AFM 67-1, you can see that the supplies used by the AF are purchased, controlled, and distributed by a complex supply system. Everything procured through supply must be needed and, in most cases, must be justified in black and white. In later objectives we will discuss the various forms you'll need to justify your need for supplies.

Let's look at the supply functions. First, it takes money—yours and mine in the form of taxes. So, in a roundabout way, you've paid for the tools and equipment you're using. In purchasing items, the AF develops specifications, and companies meeting the specifications submit bids (cost estimates). The Air Force selects the lowest bid. In this way, the Air Force receives the most for its money.

The controlling aspect is directly related to the cost of an item. The costlier an item, the stricter the controls. Everything procured (ordered) through supply must be needed, and the higher the cost the greater the justification required. The Air Force wants to get the maximum use of items it has purchased.

Distribution of supplies is based on present needs and projected future needs. An operational fighter base has a greater need than a training base. This distinction is referred to as priority. Supply uses a priority system in distributing supplies throughout the Air Force. A similar priority system is used at base level for the actual issuing of items. This system of priorities is designed to insure that an item not only is used for its intended purpose but also used by the people who have the greatest need.

Exercises (034):

1. What is the purpose of the Air Force supply system?

2. Equipment procured by the supply system must be _____ and _____

3. What manual outlines the functions of the AF supply system?

4. What is the main controlling factor of the AF supply system?

5. What factor determines the distribution of supplies?

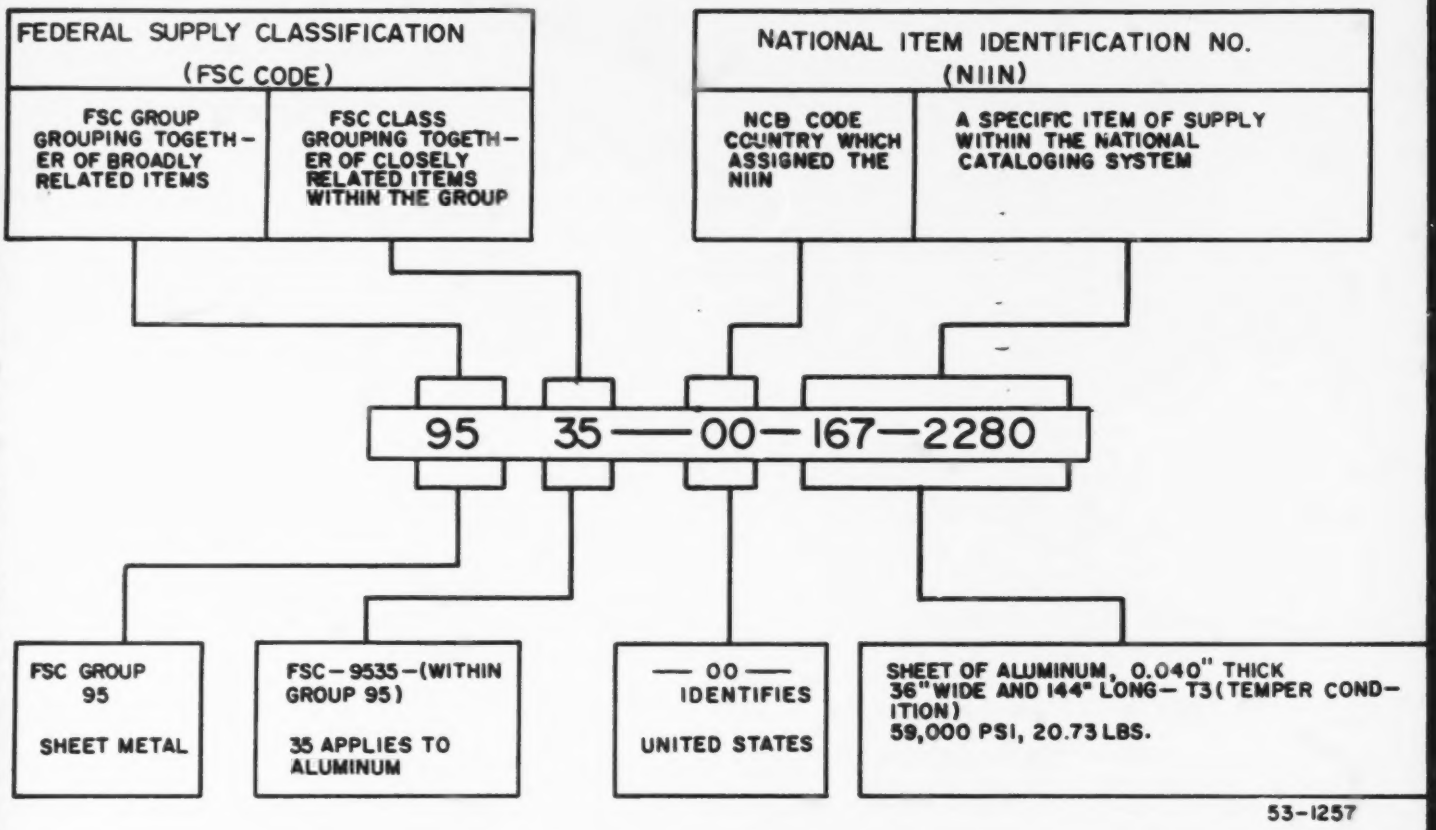
FEDERAL SUPPLY CLASSIFICATION
(FSC CODE)
FSC GROUP GROUPING TOGETHER OF BROADLY RELATED ITEMS
FSC CLASS GROUPING TOGETHER OF CLOSELY RELATED ITEMS WITHIN THE GROUP
NATIONAL ITEM IDENTIFICATION NO.
(NIIN)
NCB CODE COUNTRY WHICH ASSIGNED THE NIIN
A SPECIFIC ITEM OF SUPPLY WITHIN THE NATIONAL CATALOGING SYSTEM
95 35 — 00 — 167 — 2280
FSC GROUP 95 SHEET METAL
FSC — 9535 — (WITHIN GROUP 95) 35 APPLIES TO ALUMINUM
— 00 — IDENTIFIES UNITED STATES
SHEET OF ALUMINUM, 0.040" THICK 36" WIDE AND 144" LONG — T3 (TEMPER CONDITION) 59,000 PSI, 20.73 LBS.
53-1257

Figure 3-1. National stock number breakdown.

035. Explain the key aspects of the classification and identification system used for supplies by identifying the elements of a national stock number, citing the purpose of suffixes, and stating how a stock number may be changed.

Supply Classification and Identification System. In the day-to-day operation of an airframe repair shop numerous items are ordered from supply. The key in ordering supplies is proper identification. A verbal description of an item means little or nothing to supply personnel. You must use a numbering system developed to identify items in the supply system. Each item within the supply system is assigned a national stock number (NSN).

The NSN is a 13-digit (all numeric) number. It is divided into two main parts: the Federal Supply Classification (FSC) code and the national item identification number (NIIN). The first four digits are the FSC and they are subdivided into two-digit units. The first two-digits are the FSC group, grouping together broadly related items. The second two-digits of the FSC are the FSC class, grouping together closely related items within the FSC group. Before use let's explain the remaining portion of the NSN, look at figure 3-1. Note what the digits 95 and 35 represent.

The last nine digits are the NIIN portion of the NSN which serve the following purpose:

(1) It serves to symbolize and fix the identity of the individual item and to differentiate it concisely and permanently from all other items.

(2) This number is assigned as an item identification and there is *no* relationship between one NIIN and the next in sequence numerically.

(3) The first two-digits of the NIIN are the National Classification Bureau (NCB) code, this code identifies the country assigning the number.

(4) The remaining seven digits distinguish a specific item of supply within the Federal Cataloging System. Return to figure 3-1, noting this time the NIIN portion of NSN and what it indicates.

In certain instances, you'll see an NSN with a suffix added. The Air Force uses the suffix (1) to segregate property according to air and ground application; (2) to segregate items in a specific class for management purposes, where the FSC is too large; and (3) to combine selected groups of specialized items connected with a specific program, such as the nuclear ordnance program.

The NSNs are organized into stock lists. The stock lists are the official source for such things as item identification stock control data and the price of USAF equipment, supplies, or spare parts repeatedly authorized for procurement, stocked, stored, or issued by the AF. The stock lists are compiled and published in individual volumes on the basis of the Federal supply groups.

It is important to remember that the national stock number is merely used but not "owned" by the Air Force. Rules of the Federal Cataloging Program do not permit a change affecting the national stock number, unless all users (participants in the program) agree. This restriction is intended to preclude confusion and contamination of the item-of-supply concepts established under a national stock number.

Exercises (035):

1. Identify the individual units of the following national stock number: 4730-00-194-1089.

2. The Air Force adds suffixes to certain NSNs for what purposes?

3. How can a national stock number be changed?

036. Locate and identify specific items in the supply indexes.

Supply Indexes. Now that you know what a national stock number represents, you can use the supply indexes available. The indexes provide you with different ways of locating items within the supply system. There are a number of supply indexes, but our discussion will deal with the four you are most likely to use.

Cataloging Handbook H2-2, Numeric Index. This index is arranged numerically by groups and classes and contains, within each class, an alphabetical list of entries included in the class (see fig. 3-2). You use this index to find out what is contained within a known FSC.

Cataloging Handbook H2-3, Alphabetical Index. This index is an alphabetical list of the entries in the numeric index. Each entry is referenced to a single 4-digit FSC code number. You use this book to find the group and class of an item if you have some idea of its correct name (see fig. 3-3).

C-RL-1, Master Cross-Reference Index. This is a listing of manufacturer's part numbers cross-referenced to their codes and NSN sequence. All known approved part numbers are listed in alphabetic-numeric sequence. You use this index when you know the manufacturer's part number and need to find the NSN.

C-RL-2, Master Cross-Reference Index. This is a listing of manufacturer's part numbers cross-referenced to their codes and NSN sequence. The current C-RL-2 index is in a three-column format with the third column in NIIN sequence. These numbers are

Class 2830

Water Turbines and Water Wheels; and Components

Turbines, water.
Water turbines.
Water wheels.

Class 2835

Gas Turbines and Jet Engines, except Aircraft; and Components

Afterburners, jet engine.
Afterburners, turbine engine. (2)
Airborne auxiliary gas turbine power units, engine starting.
Auxiliary gas turbine power units, airborne, engine starting.
Auxiliary gas turbine power units, ground, engine starting.
Blades, compressor rotor, turbine engine. (2)
Blades, turbine, jet engine.
Blades, turbine rotor, turbine engine. (2)
Blade sets, compressor rotor, turbine engine. (2)
Blade sets, turbine rotor, turbine engine. (2)
Carriers, planetary reduction gear, turbine engine. (2)
Cases, axial compressor, turbine engine. (2)
Cases, centrifugal compressor, turbine engine. (2)
Cases, combustion chamber, turbine engine. (2)
Cases, turbine rotor, turbine engine. (2)
Case and nozzles, turbine, turbine engine. (2)
Case and vane assemblies, axial compressor, turbine engine. (2)
Chambers, combustion, turbine engine. (2)
Compressors, axial, turbine engine. (2)
Compressor rotors, axial, turbine engine. (2)
Compressor rotors, axial-centrifugal, turbine engine. (2)
Compressor rotors, centrifugal, turbine engine. (2)
Cones, exhaust, turbine engine. (2)
Disks, axial compressor, turbine engine. (2)
Disks, turbine, turbine engine. (2)
Disk and hubs, axial-centrifugal compressor, turbine engine. (2)
Disk and hubs, axial compressor, turbine engine. (2)
Disk and hubs, turbine, turbine engine. (2)
Ducts, exhaust, turbine engine. (2)
Duct and cones, exhaust, turbine engine. (2)
Engines, gas turbine. (1)
Engines, jet.
Flameholders, afterburner, turbine engine. (2)
Gas expansion turbines, aircraft refrigeration.
Gas turbines.
Gas turbine engines.
Gas turbine engine power units.
Gearboxes, accessory drive, turbine engine. (2)
Housings, antifriction bearing, turbine engine. (2)
Housings, gearbox, turbine engine. (2)
Housings, oil pump, turbine engine. (2)
Housings, reduction gear, turbine engine. (2)
Hubs, compressor rotor, turbine engine. (2)
Hubs, turbine, turbine engine. (2)
Insulation blankets, thermal, turbine engine. (2)
Jet engines.
Jet engine afterburners.
Jet engine turbine blades.
Nozzles, lubricating, turbine engine. (2)
Nozzles, turbine, turbine engine. (2)
Oil pumps, jet engine.
Power units, gas turbine engine. (1)
Power units, gas turbine engine, rocket spinning. (1)
Power unit sets, gas turbine engine, pneumatic. (1)
Pumps, oil, jet engine.
Rocket spinning gas turbine engine power units.
Shafts, propeller, turbine engine. (2)
Shafts, turbine, turbine engine. (2)
Shields, heat, turbine engine. (2)
Tanks, lubricating oil, turbine engine. (2)
Turbines, gas. (2)
Turbines, gas expansion, aircraft refrigeration.
Turbine blades, jet engine.
Turbine engines, gas.
Turbine engine accessory drive gearboxes.
Turbine engine afterburners.
Turbine engine afterburner flameholders.
Turbine engine antifriction bearing housings.
Turbine engine axial compresaors.
Turbine engine axial compressor cases.
Turbine engine axial compressor case and vane assemblies.
Turbine engine axial compressor disks.
Turbine engine axial compressor rotors.
Turbine engine axial-centrifugal compressor rotors.
Turbine engine centrifugal compressor cases.
Turbine engine centrifugal compressor rotors.
Turbine engine combustion chambers.
Turbine engine combustion chamber cases.
Turbine engine compressor rotor blades.
Turbine engine compressor stator vanes.
Turbine engine counterbalance weights.
Turbine engine exhaust cones.
Turbine engine exhaust ducts.
Turbine engine exhaust duct and cones.
Turbine engine gearbox housings.
Turbine engine heat shields.
Turbine engine lubricating nozzles.
Turbine engine lubricating oil tanks.
Turbine engine oil pump housings.
Turbine engine planetary reduction gear carriers.
Turbine engine propeller shafts.
Turbine engine reduction gear housings.
Turbine engine stator vane assemblies.
Turbine engine thermal insulation blankets.
Turbine engine turbine case and nozzles.
Turbine engine turbine disks.
Turbine engine turbine nozzles.
Turbine engine turbine nozzle vanes.
Turbine engine turbine rotors.
Turbine engine turbine rotor blades.
Turbine engine turbine rotor blade sets.
Turbine engine turbine rotor cases.
Turbine engine turbine shafts.
Turbine rotors, turbine engine. (2)
Vanes, compressor stator, turbine engine. (2)
Vanes, turbine nozzle, turbine engine. (2)
Vane assemblies, stator, turbine engine. (2)
Weights, counterbalance, turbine engine. (2)

Class 2840

Gas Turbines and Jet Engines, Aircraft; and Components

Afterburners, jet engine.
Afterburners, turbine engine. (2)
Blades, compressor rotor, turbine engine. (2)
Blades, turbine, jet engine.
Blades, turbine rotor, turbine engine. (2)
Blade sets, compressor rotor, turbine engine. (2)
Blade sets, turbine rotor, turbine engine. (2)
Carriers, planetary reduction gear, turbine engine. (2)
Cases, axial compressor, turbine engine. (2)
Cases, centrifugal compressor, turbine engine. (2)
Cases, combustion chamber, turbine engine. (2)
Cases, diffuser, turbine engine. (1)
Cases, turbine rotor, turbine engine. (2)
Case and nozzles, turbine, turbine engine. (2)
Case and vane assemblies, axial compressor, turbine engine. (2)
Chambers, combustion, turbine engine. (2)
Compressors, axial, turbine engine. (2)
Compressor rotors, axial, turbine engine. (2)
Compressor rotors, axial-centrifugal, turbine engine. (2)
Compressor rotors, centrifugal, turbine engine. (2)
Cones, exhaust, turbine engine. (2)
Disks, axial compressor, turbine engine. (2)
Disks, turbine, turbine engine. (2)
Disk and hubs, axial-centrifugal compressor, turbine engine. (2)
Disk and hubs, axial compressor, turbine engine. (2)
Disk and hubs, turbine, turbine engine. (2)
Ducts, exhaust, turbine engine. (2)
Duct and cones, exhaust, turbine engine. (2)
Engines, aircraft, turbo-prop. (1)
Engines, jet.
Engines, pulse-jet. (1)
Engines, ramjet. (1)
Engines, turbo-jet. (1)
Engines, turbo-prop.
Engine built-up units, aircraft. (2)
Flameholders, afterburner, turbine engine. (2)
Gearboxes, accessory drive, turbine engine. (2)
Housings, antifriction bearing, turbine engine. (2)
Housings, gearbox, turbine engine. (2)
Housings, oil pump, turbine engine. (2)
Housings, reduction gear, turbine engine. (2)
Hubs, compressor rotor, turbine engine. (2)
Hubs, turbine, turbine engine. (2)
Insulation blankets, thermal, turbine engine. (2)
Jet engines.
Jet engine afterburners.
Jet engine turbine blades.
Nozzles, lubricating, turbine engine. (2)
Nozzles, turbine, turbine engine. (2)
Oil pumps, jet engine.
Pulse-jet engines.
Pumps, oil, jet engine.
Ramjets, engine.
Reservoirs, hydraulic tank, oil.
Shafts, propeller, turbine engine. (2)
Shafts, turbine, turbine engine. (2)
Shields, heat, turbine engine. (2)

Figure 3-2. Cataloging Handbook H2-2, Numeric Index.

prefixed by the FSC. You use this index when you know the NSN and need the manufacturer's part number and code.

Exercises (036):
Refer to figures 3-2 and 3-3 to answer the first two questions.

1. What is the FSC for hinges?
2. What type of items are contained in FSC 2830?
3. Which cross-reference index is used when you need to locate the manufacturer's part numbers?

4. Which cross-reference index lists the NIIN in sequence?

5. Part numbers are listed in an alphabetic-numeric sequence in which cross-reference index?

037. Given individual steps associated with the three methods of locating information in supply catalogs, explain the purpose of the steps.

USAF Federal Supply Catalogs. What you know about an item dictates the method you use to locate information about the item. Indexes provide the starting point and catalogs provide the additional informa-

	Class
Guy wire	
steel	9505
stranded	4010
Guy wire clamps	4030
Gymnasium shoes	
men's	8430
women's	8435
Gymnastic equipment	7830
Gypsies (capstans)	3950
Gypsum board	5640
Gypsum cement	5610
Gypsum lath	5640
Gypsum panels	5640
Gypsum planks	5640
Gypsum plaster	5610
Gypsum plasterboard	5640
Gypsum sheathing	5640
Gypsum tiles	5620
Gypsum wallboard	5640
Gyros	
azimuth	6615
torpedo	1355
Gyro and motor assemblies, gunsight stabilizing, aircraft	1270
Gyro angle transmitters, fire control, except airborne	1265
Gyro assemblies	
automatic stabilization, helicopter	6615
gunnery deflection, aircraft	1270
Gyro bank and climb controls	6615
Gyro caging controllers, induction compass	6605
Gyro compasses	6605
Gyro controls, hydraulic surface	6615
Gyro flight rate controls	6615
Gyro heater sets (1)	6615
Gyro horizon indicators	6610
Gyro mechanisms, space vehicle	1820
Gyro mechanisms (complete)	
aircraft bombing	1280
aircraft gunnery fire control	1270
navigational	6605
guided missile	1420
Gyro oil	9150
Gyro stabilizers	
75mm howitzer	1250
105mm howitzer	1250
Gyro storage ovens	4430
Gyroscopes	
demonstrator	6910
displacement, except nonairborne (3)	6615
integrating, except nonairborne (3)	6615
rate, except nonairborne (3)	6615
Gyroscope controls, guided missile tail	1420
Gyroscope signal simulators, except specially designed	6625
Gyroscopic aiming devices, fire control	1290
Gyrosphere flotation oil	9150
Gyroswitches	
rate, except nuclear ordnance (2)	6615
rate, nuclear fuzing and firing (2)	1135
rate, training, except nuclear fuzing and firing (2)	6930

H

H frame derricks	3950
H-sections	
aluminum	9540
aluminum alloy	9540
Hack, band and circular saw blade filing machines, combination	3405
Haddock, frozen (1)	8905
Hafts, saddler's awl (1)	5120
Hair	
animal, curled (1)	8320
viola bow	7720
violoncello bow	7720
Hair cinchas	3770
Hair clipping sets, veterinary (1)	3770
Hair net	8315
Hairbrushes (1)	8530
Halazone tablets, NF (1)	6505
Half adder integrated circuits	5962
Half and half (ale and porter)	8965
Half and half (1)	8910
Half and half, sour (1)	8910
Half hinges	
butt	5340
continuous	5340
Half round molding, wood	5510
Half shift register integrated circuits	5962
Half-tanks and undercarriages, mobile respirator (1)	6530
Halftracks, armored	2350
Halibut, frozen (1)	8905
Haloperidol solution (1)	6505
Haloperidol tablets (1)	6505
Halothane, USP (1)	6505
Halters, horse-mule (1)	3770
Halyards	
antenna, multiapplication (3)	5985
banner (3)	8345
flag (3)	8345
multiapplication (3)	4020
pennant (3)	8345
sail (3)	2090
Halyard cleats	5340
Ham	
canned, dietetic (2)	8940
canned, except dietetic (2)	8905
cooked, chilled (1)	8905
cooked, frozen (1)	8905
smoked, chilled (1)	8905
smoked, frozen (1)	8905
Ham and eggs, canned (1)	8940
Ham and lima beans, canned (1)	8940
Ham hocks, unsmoked, chilled (1)	8905
Hamamelis water (1)	6505
Hambroline	4020
Hamburger	8905
Hamburgers without gravy, canned (1)	8905
Hammers	
bumping, power (1)	3446
chimes	7720
chipping, pneumatic	5130
claw, explosive ordnance disposal, underwater type	1386
cross peen, explosive ordnance disposal, underwater type	1386
double faced, explosive ordnance disposal, surface type	1385
electric, portable (1)	5130
firing, grenade launcher, through 30mm (2)	1005
firing, grenande launcher, over 30mm up to 75mm (2)	1010
firing, grenade launcher, 75mm through 125mm (2)	1015
firing, small arms (1)	1005
forging, helve	3446
forging, impact	3446
hand, carpenters', explosive ordnance disposal, surface type (2)	1385
hand, except explosive ordnance disposal type (2)	5120
jam riveting, pneumatic	5130
percussion, medical	6515
pile driver, air-steam driven (1)	3895
pile driver, drop (1)	3895
pile driver, self-powered (1)	3895
pneumatic, portable (1)	5130
postmortem	6515
power, electric	5130
reflex, testing (1)	6515
riveting, pneumatic	5130
scaling, electric	5130
track spike, gasoline engine driven (1)	2230
Hammer calking tools, power	5130
Hammer faces	
inserted, except explosive ordnance disposal, type	5120
inserted, explosive ordnance disposal, underwater type	1386
Hammer face holders	
inserted, except explosive ordnance disposal, type	5120
inserted, explosive ordnance disposal, underwater type	1386
Hammer mill crushers	3820
Hammer tips, cellulose	5120
Hammer-brushes, welders' (1)	5120
Hammerhead cranes	3950
Hammocks	
except jungle type (2)	7195
jungle (2)	8465
Hammock clew assemblies (1)	7195
Hampers	
ammunition, with internal fittings	8140
clothes	7240
soiled linen (1)	7240
Hand clamps	5120
Hand cleaners (1)	8520
Hand flour sifters	7330
Hand grenade igniters	1330
Hand grenade safety clips	1330
Hand jack kits, hydraulic	5120
Hand levels, surveying	6675
Hand linkers	4925
Hand lubricating guns	4930
Hand megaphones	8465
Hand mowers, lawn	3750
Hand press seals	7520
Hand protectors, shooters' (1)	8415
Hand screws (1)	5120
Hand screw jack extension caps	5120
Hand stamp duplicating stencils	7530
Hand starters, engine, except aircraft and guided missile prime moving	2990
Hand towel sets, medical field use	6545
Hand tractors, garden	3750
Hand trucks	3920
Hand truck adapter kits	
general purpose	3920
nuclear ordnance	1190
Hand wraps, boxers' (1)	7810
Hand-rifle grenades	1330
Handbags, women's (1)	8445
Handballs (1)	7810
Handbooks, technical	7610
Handcarrying plastic baskets	7240
Handcarts	
garment, laundry (1)	3510
general purpose	3920
grocery (1)	7290
mail (1)	7290
shirt, laundry	3510
Handcrank arms, multiapplication	5340
Handcuffs (1)	8465
Handcuffs cases	8465
Handhole diaphragms, pressurizer, nuclear reactor	4470
Handhole parts, boat	2040
Handicraft kits	
costume jewelry (1)	7820

Figure 3-3. Cataloging Handbook, H2-3, Alphabetical Index.

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tion needed to order specific supply items. USAF catalogs are developed for each FSC that contains items used by the Air Force. You will have to use these catalogs to fill out the necessary forms for ordering supplies.

USAF Federal supply catalogs are "tailored" publications for Air Force use only. These publications contain all items used by the Air Force regardless of the method of management or the source of supply. A complete USAF Federal supply catalog consists of two separate publications, the USAF Management Data List (ML-AF) and the USAF Identification List (IL-AF).

USAF Management Data List (ML-AF). The Management Data List provides requisitioners with minimum data necessary to acquire and account for an item of supply. Each ML-AF is related to a corresponding IL-AF. Items in the ML-AF are arranged in national stock number sequence and contain such information as the item status, source category, price, and description.

USAF Identification List (IL-AF). The Identification List provides, in printed form, the Federal item identification and related data required to identify or select items of supply. The identification list consists of an alphabetical index, a national stock number index, a manufacturer's index, an information table, and illustrations. It is used when a national stock number is known, when descriptive data or dimensions are required, and when the name of the item is known and the NSN is required.

A catalog number C5130-IL or ML-AF signifies the following:

(1) C—indicates a Federal supply catalog publication.

(2) 5130—represents the FSC.

(3) IL—indicates identification list, ML—management data list.

(4) AF—denotes the individual service publication.

Researching Methods. The first method is research by name. Suppose you need to find the stock number of a 16-ounce tinner's hand riveting hammer. First, determine the group class by using the alphabetical index (H2-3) and looking under the listing "Hammers, Hand." You will find it in class 5120. This gives you the first four digits of the stock number. Next, use the alphabetical lists in DOD Federal Supply Catalog C5120-IL-AF to find "Hammers, Hand Riveting." Here you find the nomenclature and the identifying numbers to complete the stock number. In this case, the stock number is 5120-00-224-4113 and the complete nomenclature is "Hammer, Hand: Tinner's Riveting. Style 6, Section A, Ref DWG Group 84, FED GGG-H-96, Type IX, Class 1." To be sure that you have the right hammer, look in the front of the catalog to find Section A and the illustration of group 84 and style 6. To find the unit of issue, source category, and cost, look in the ML section. Stock numbers are listed numerically, and under stock number 5120-00-224-4113, you will find that the item is local purchase (LP), the unit of issue is EA (each), the cost, and the source category is the General Services Administration (GSA).

The second method is research by stock number. Suppose that you already have stock number 5120-00-224-4113 and wish to find the item description. In the index section of DOD Federal Supply Catalog C5120-IL-AF, the stock numbers are listed numerically. In this case, the index number for stock number 5120-00-224-4113 is 100080-600. Using this index number, which is a locator number for quick reference, turn to the item description section of the catalog, which is arranged numerically by index number. Index number 100080-600 is followed by a description of "Hammer, Hand Riveting."

The third method is research by part number. Suppose you need the stock number but you know only the item description for the piece of equipment and the manufacturer's identifying part number. Using *Cross-Reference Index,* C-RL-1, which lists part numbers numerically, you can locate the one you need. On the same line with this part number you will find the corresponding stock number. By using this stock number in the IL index, the corresponding index number can be found. With the index number, it is a simple matter to find the item description. When you are researching by part number, be sure that the item description is for the right part or piece of equipment.

Exercises (037):

1. Why is it necessary to consult handbook H2-3 when researching supply information by name?

2. If you know the specific group class and nomenclature of an item, why must you still consult the IL supply catalog when researching by name?

3. If you know the correct stock number, why is it necessary to consult the IL catalog?

4. If you have the correct part number of an item, why must you consult C-RL-1 index?

5. If you know the correct stock number, why would you consult the ML listing of a specific group class catalog?

038. Match the terms related to the codes used for document numbers on supply forms with their definitions, and identify individual parts of a document number.

Before getting into the different types of supply forms, there are certain terms and codes associated with supply forms that you must know. This will make your job of filing these forms much easier. As we progress into the different forms, you'll see how these codes and terms reoccur from form to form.

Document Numbers. Most of the transactions you process with base supply are assigned an organizational document number composed of 14 alphabetic and numeric characters. It is a control or reference number that is used to identify an individual, specific transaction. For example, R622HS31240019:

R—Activity code (1 alphabetic character—1st position of the document number).

622—Organizational code (3 numbers—2nd through 4th positions).

HS—Shop code (2 alphabetic characters—5th and 6th positions).

3124—Julian date (4 numbers—7th through 10th positions).

0019—Serial number (4 numbers—11th through 14 positions).

Activity code. This code identifies the method or location used by an organization in processing an issue or turn-in request to base supply. In some cases, it further identifies the type of item; for example: bench stock, war reserve material, etc. The codes are listed in AFM 67-23, *Standard Base Supply Customer's Manual,* Chapter 2.

Organizational code. This code is used to specifically identify your unit or subordinate activities. These codes are assigned by the base in specific series, as directed by AFM 67-1. These same codes are used to maintain dollar data on the supplies and equipment drawn from or turned-in to base supply by your organization.

Shop code. This code further identifies the shop within your organization. AFM 67-1 suggests standard codes for certain functions. Each shop will have its own shop code.

Julian date. The Julian date consists of four digits. The first digit is the year. The last three digits represent the day of the year. For example, the Julian date 3124 represents the 4th of May 1973.

Serial number. These numbers are assigned beginning with 0001 daily for each activity code. They are manually assigned, normally, by base supply.

Exercises (038):

1. Match the term in column B, with the definition in column A that is most appropriate for that term.

Column A	*Column B*
_____ *1.* Represents a specific day of the year.	a. Activity code.
_____ *2.* Assigned at beginning of each day.	b. Organizational code.
_____ *3.* Identifies a specific unit within a squadron.	c. Shop code.
_____ *4.* Identifies the method used by an organization in processing an issue or turn-in request to base supply.	d. Julian date.
_____ *5.* Identifies a specific unit on base.	e. Serial number.

2. In the space provided, write in the part of stock number J629EB41510050 that is indicated by the term.

_____ a. Julian date.

_____ b. Activity code.

_____ c. Serial number.

_____ d. Shop code.

_____ e. Organizational code.

039. Correct the entries on an issue/turn-in request.

Locating the necessary information for ordering supplies is the first step toward receiving the needed supplies. The information that you have obtained through research will determine the next step—what form to use in placing your request to base supply. AF Form 2005 provides one method.

AF Form 2005, Issue/Turn-in Request. This form is used for ordering supplies, both expendable and nonexpendable, that have a national stock number. You may be required to fill one out if you need a part. Your supply custodian will help you, or you may consult AFM 67-23, *Standard Base Supply Customer's Manual,* Step-by-step procedures for filling out the various forms used by supplies custodians are described in this manual.

Figure 3-4 illustrates an AF Form 2005. Refer to this figure during the following discussion of the required entries.

Block 1 identifies the type of request as either issue or turn-in. Block 2 is the delivery destination (your shop location code). In block 3, be sure to include your name, time of request, date, and extension. The next three blocks are very important; make sure your entries are correct. The NSN is recorded in block 4, and

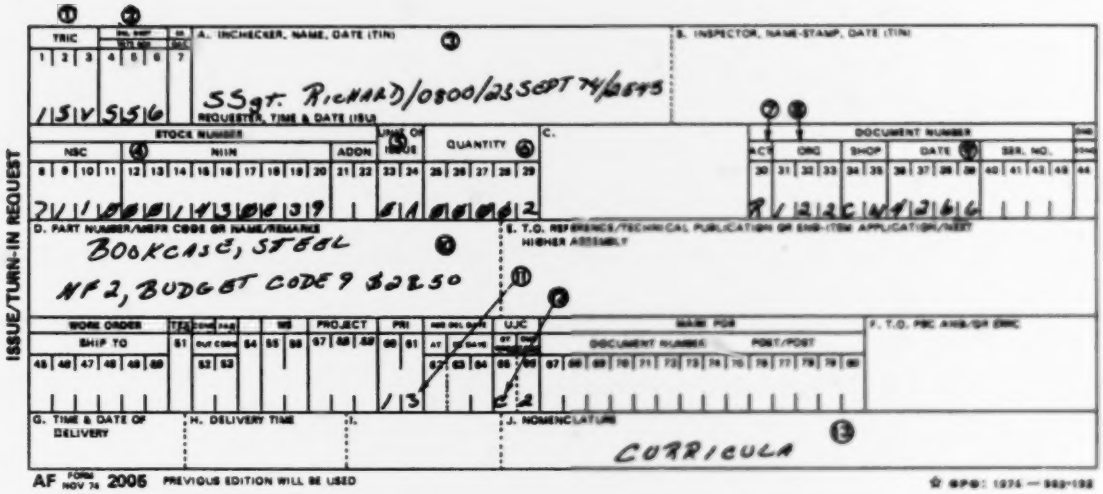


Figure 3-4. AF Form 2005, Issue/Turn-in Request.

the unit of issue in block 5. Examples of unit of issue code are: each (EA), box (BX), dozen (DZ), hundred (HD), and feet (FT). The quantity, block 6, should be preceded by slashed zeros to fill out the spaces in that block. The slashing of the zeros is to eliminate the possibility of the zeros being taken for the letter "O". Block 7 is taken from a code list in AFM 67-23, and block 8 is your shop account number. Enter the Julian date in block 9. In block 10, you must include the nomenclature of the NSN, the budget code if the item is equipment, and the cost. Block 11, priority and block 12, urgency justification code, can be found in AFM 67-23. The last block, 13, is the destination of the item such as the curricula unit or airframe repair tool crib.

Exercises (039):

1. Refer to figure 3-5 and identify the errors made in completing AF Form 2005.

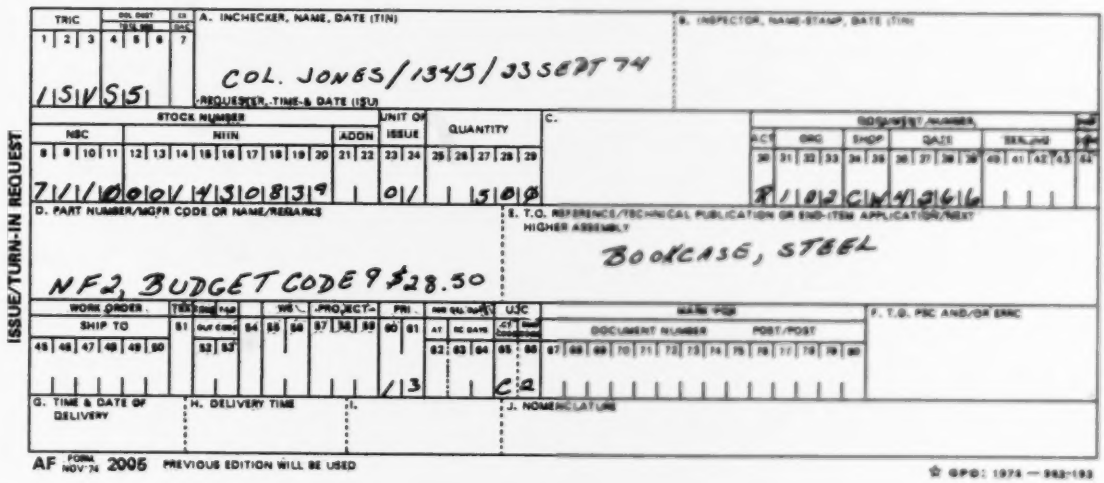


Figure 3-5. Objective 039, exercise 1.

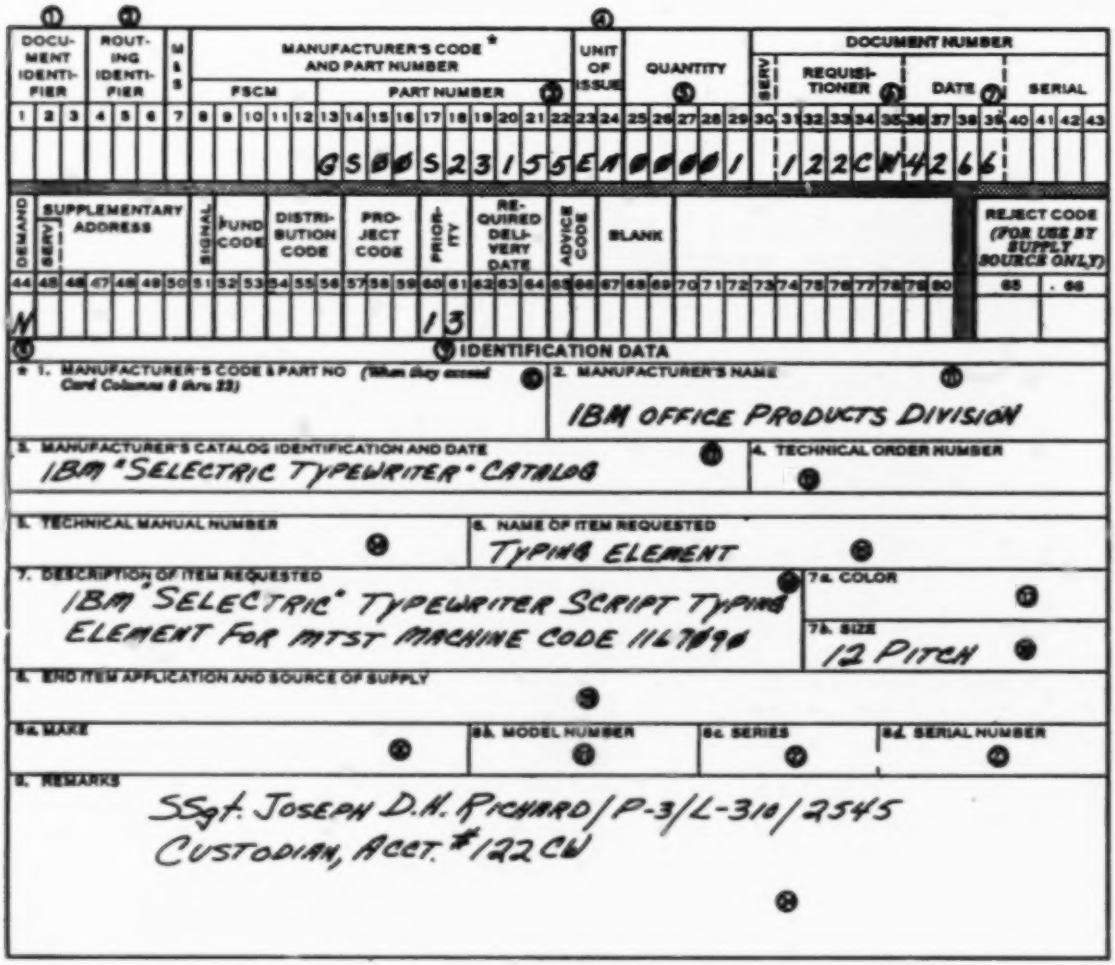


Figure 3-6. DD Form 1348-6, Non-NSN Requisition.

040. State the purpose of a DD Form 1348-6 and identify specific data on a DD Form 1348-6.

DD Form 1348-6, Non-NSN Requisition, shown in figure 3-6, provides a second method of ordering supplies. This is the form to use when you need a part that does not have a national stock number and must be obtained through local purchase.

Refer to figure 3-6 as we discuss the form. Blocks 1 and 2 will be filled in by supply. Fill in block 3, the manufacturer's part number, if you have it, and if not, leave it blank. The unit of issue, block 4, may be EA, BX, DZ, HD, or any other way the part is issued. The quantity, block 5, is the number of units desired. All spaces should be filled with slashed zeros as shown. Your supply custodian can help you with blocks 6 through 9. Block 6 is your supply account number; 7 is the Julian date; 8 is the demand; and 9 is the priority, which must be taken from AFM 67-23. Blocks 10 through 15 are self-explanatory and depend on your source of information. Block 16 is very important. This block must give a very detailed description of the part required to insure the purchase of the correct part. Blocks 17 through 23 are again self-explanatory. Another important block to complete is block 24. Make sure you include your name, location, and telephone extension. This allows supply to contact you if questions arise concerning the purchase of the part or a possible substitute.

Exercises (040):

1. When would it be necessary to use a DD Form 1348-6?

NOTE Refer to figure 3-6 for the following questions.

2. What is the Julian date given?

3. What is the supply account number given?

4. Why is the entry in block 16 very important?

5. Why is the entry in block 24 very important?

041. Differentiate between the types of issue slips in terms of required entries and use.

When you receive items from supply, some types of issue slips must be signed. This serves two purposes. First, it provides supply with a record of issues, and secondly, it holds you accountable for the items received. The following two issue slips require your signature for purposes of accountability.

DD Form 1348-1, DOD Single Line Item Release/ Receipt Document. This form is initiated by supply when they receive your request for supplies. Portions of the block entries are taken directly off the form which you used in making the request. Your direct involvement occurs when the item you ordered is delivered to the shop. At that time you must check this form to see if the item is what you ordered. If the item is what you ordered, then fill out the bottom line, blocks 13, 14, and 15 of DOD Form 1348-1. Block 13 requires the Julian date and time you receive the item. In block 14, enter your signature, and then print your name and rank in block 15. Figure 3-7 illustrates a completed DD Form 1348-1. The printed titles shown for blocks 13 and 15 are used by supply for other functions requiring the use of this form.

AF Form 1297, Temporary Issue Receipt. This form is used to issue an item of equipment for a short time. You fill out this form each time to check out an item from the tool crib in the airframe repair shop. Figure 3-8 indicates entries required on this form. All entries are self-explanatory. The large "X" across the description block prevents additional items being added after you have signed the form. Upon returning the item to the tool crib, make sure you receive your receipt.

Exercises (041):

1. When is it necessary to fill out an AF Form 1297?

2. In what ways does an airframe repairman get involved with DD Form 1348-1?

3. What entries does an airframe repairman fill out on DD Form 1348-1 when receiving supplies?

4. What function do issue slips serve?

042. Cite the ways an AF Form 601b may be used, and identify factors related to the required entries.

The previously discussed forms all dealt with receiving items from supply. Certain supply forms have a dual purpose—both issue and turn-in. AF Form 2005 is one that we have covered already. Block 1 of AF Form 2005 (fig. 3-4) indicates how the form is being used. In certain situations, a DOD Form 1348-1 is used for turn-in also. Our discussion in this objective segment will center around AF Form 601b, Custodian Request/ Receipt (see fig. 3-9).

AF Form 601b. This is a dual-purpose form. It can be used for turn-in and issue. Referring to figure 3-9, you see that the example shown is being used for replacement of condemned equipment. Blocks 8 through 11 are very important in requesting equipment.

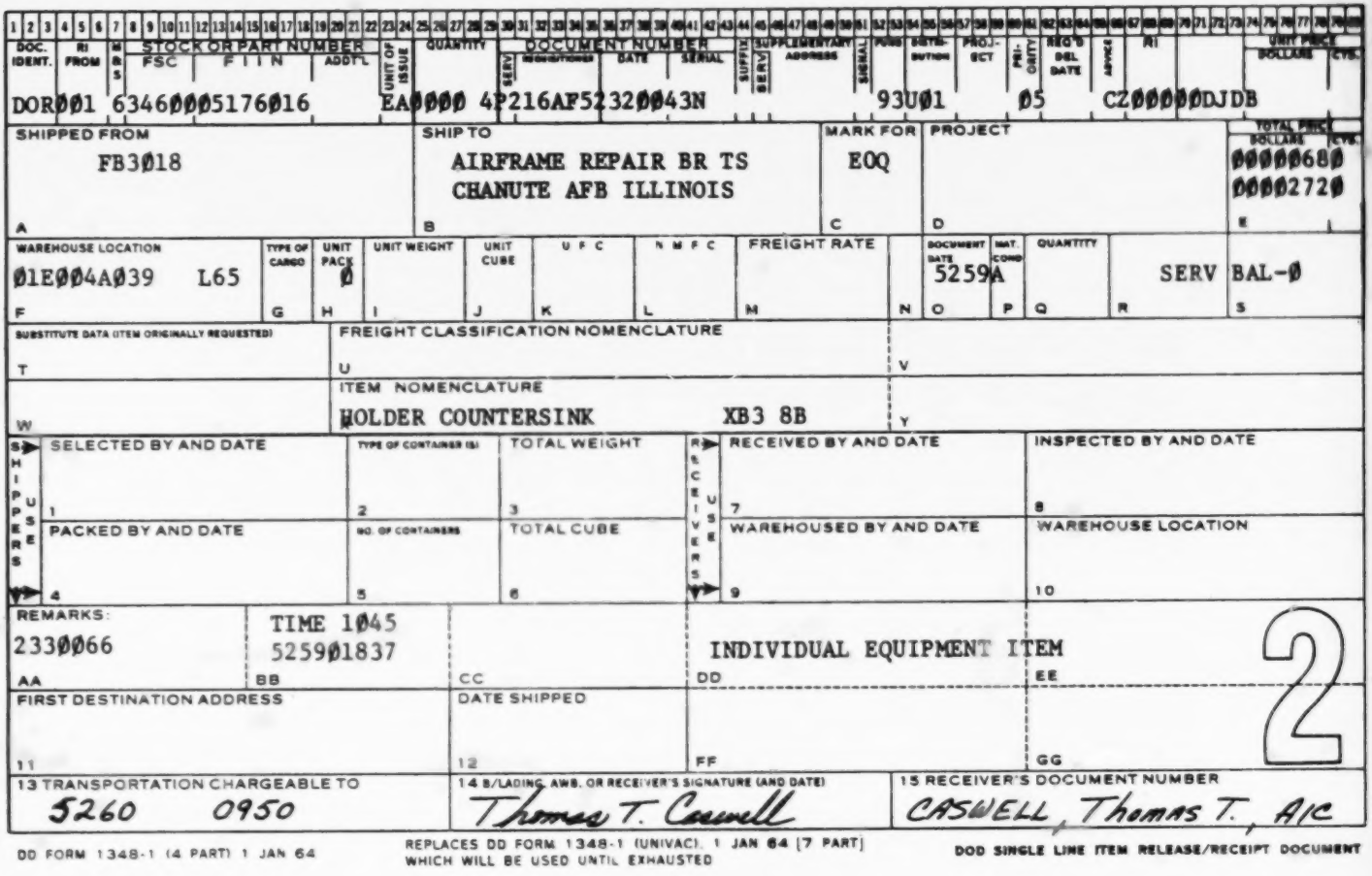
The amount of equipment a shop is allowed to have is listed in Table of Allowances (TAs). TAs must be checked before ordering equipment. As you see, in block 8 of figure 3-9, 18 heaters are authorized. All heaters are in use as indicated in block 9. The request for replacement is to maintain the authorized level of 18, as shown in block 10. Block 11 is the number requested (5). Block 22 is used to record your justification for ordering the items. Procedures for filling out this are listed in AFM 67-23.

Exercises (042):

1. Why is the AF Form 601b called a dual-purpose form?

2. What type of supply transaction is taking place in figure 3-9?

3. Where would you look to obtain the correct entry for block 8, of the AF Form 601b in figure 3-9?



DOC. IDENT.	RI FROM	M & S	STOCK OR PART NUMBER FSC	FIIN	ADD'L	UNIT OF ISSUE	QUANTITY	DOCUMENT NUMBER SERV	DATE	SERIAL	SUFFIX	SUPPLEMENTARY ADDRESS SERV	SERIAL	PURP	DISTRIBUTION	PROJECT	PRIORITY	REQ'D DEL DATE	ADVICE	RI	UNIT PRICE DOLLARS	CTS.
DOR	001		6346	000517	6016	EA	0000	4P216	AF523	20043N				93U	01		05		CZ	000000	DJDB	

SHIPPED FROM	SHIP TO	MARK FOR	PROJECT	TOTAL PRICE DOLLARS	CTS.
FB3018	AIRFRAME REPAIR BR TS CHANUTE AFB ILLINOIS	EOQ		00000680	
A	B	C	D		00002720 E

WAREHOUSE LOCATION	TYPE OF CARGO	UNIT PACK	UNIT WEIGHT	UNIT CUBE	U P C	N M F C	FREIGHT RATE		DOCUMENT DATE	MAT. COND	QUANTITY		
01E004A039 L65		0							5259A			SERV	BAL-0
F	G	H	I	J	K	L	M	N	O	P	Q	R	S

SUBSTITUTE DATA (ITEM ORIGINALLY REQUESTED)	FREIGHT CLASSIFICATION NOMENCLATURE	
T	U	V
W	ITEM NOMENCLATURE HOLDER COUNTERSINK XB3 8B	Y

SHIPPER'S USE				RECEIVER'S USE		
SELECTED BY AND DATE	TYPE OF CONTAINER (S)	TOTAL WEIGHT		RECEIVED BY AND DATE		INSPECTED BY AND DATE
1	2	3		7		8
PACKED BY AND DATE	NO. OF CONTAINERS	TOTAL CUBE		WAREHOUSED BY AND DATE		WAREHOUSE LOCATION
4	5	6		9		10

REMARKS:				
2330066	TIME 1045 5259 01837		INDIVIDUAL EQUIPMENT ITEM	2
AA	BB	CC	DD	EE
FIRST DESTINATION ADDRESS	DATE SHIPPED			
11	12		FF	GG

13 TRANSPORTATION CHARGEABLE TO	14 B/LADING, AWB, OR RECEIVER'S SIGNATURE (AND DATE)	15 RECEIVER'S DOCUMENT NUMBER
5260 0950	Thomas T. Caswell	CASWELL, THOMAS T., A1C

DD FORM 1348-1 (4 PART) 1 JAN 64 — REPLACES DD FORM 1348-1 (UNIVAC), 1 JAN 64 (7 PART) WHICH WILL BE USED UNTIL EXHAUSTED — DOD SINGLE LINE ITEM RELEASE/RECEIPT DOCUMENT

Figure 3-7. DD Form 1348-1.

TYPED OR PRINTED NAME, GRADE AND ORGANIZATION	TO: (Responsible Officer)	ORG. ACCT. NO.	DATE ITEM(S) TO BE RETURNED
	Sgt. KILN	216 AF	1 NOV 75

STOCK NO.	DESCRIPTION	UNIT	QUANTITY ISSUED	COST
4430-00-79-2118	HEATER, HONEYCOMB	EA	1	$105.00
	LAST ITEM			

I ACKNOWLEDGE RECEIPT AND RESPONSIBILITY FOR ITEM(S) SHOWN IN "QUANTITY ISSUED" COLUMN, WHICH WILL BE RETURNED ON DATE SPECIFIED ABOVE.

DATE	SIGNATURE	DUTY PHONE	ISSUED BY
31 Oct 1975	George Clison	2814	C. Latham

AF FORM SEP 70 1297 PREVIOUS EDITIONS WILL BE USED **TEMPORARY ISSUE RECEIPT** * GPO : 1973 O - 503 - 973

Figure 3-8. AF Form 1297, Temporary Issue Receipt.

043. State the correct supply condition tag to use in given situations.

The condition of parts within the supply system are closely monitored, especially if the part is limited in numbers and is expensive. In the course of your work, you'll use three types of condition tags. They permit easy identification of the condition of a part.

Serviceable Tag—Materiel, DD Form 1574. This tag is yellow in color and is used on all new parts, on serviceable parts being returned to supply, and on parts that have been repaired. Figure 3-10 is an example of a serviceable tag with typical entries.

Unserviceable (Reparable) TAg—Materiel, DD Form 1577-2. Figure 3-11 is an example of an unserviceable (reparable) tag. The entries are basically the same as the serviceable tag except that the reason for the reparable condition must be indicated. This tag is green in color and is used on parts that can be repaired and made serviceable without exceeding 75 percent of the parts' cost.

Unserviceable (Condemned) Tag—Materiel, DD Form 1577. Figure 3-12 illustrates an unserviceable (condemned) red tag. The entries are very similar to those on the other two tags except that a reason or authority indicating why the part is condemned is required. This tag is used on parts that cannot be repaired or whose repair costs would exceed 75 percent of its original cost. Once this tag is placed on a part by proper authority, the part must not be used for any reason.

Authorized inspectors are the only ones allowed to fill out condition tags. A technician within the airframe repair shop is usually assigned this authority. But, as a specialist, you must know what each indicates and the important role the tags have in the overall supply system.

Exercises (043):

1. A part sent off to the maintenance depot for repairs requires what type of supply condition tag?

2. After a part has been repaired, which type of supply condition type tag is required?

3. How does the cost of repairing a part affect the type of supply condition tag required?

4. What supply condition tag is placed on parts stored in supply?

1. NAME OF CUSTODIAN-PHONE NUMBER-ORGANIZATION/ CUSTODIAN CODE	2. CUSTODIAN REQUEST NO.	3. BEMO/ EMO CONTROL NO.	4. AF FORM 601A CONTROL NO.
TSgt. KINN/3841/216 AF/STOP 62	AF-5362-10		

5. STOCK NO. AND/ OR PART NO.	6. IN-USE DETAIL DOC. NO.	7. ALLOWANCE IDENT.	8. PRESENT QNTY AUTH.	9. QNTY. IN USE INCLUDE SUBS	10. QNTY. REQ'D NEW AUTH.	11. QNTY. REQUESTED	12. UNIT OF ISSUE	13. UNIT COST	14. UND	15. FAD	16. USE CODE
4430-00-789-2918	0162	757AE0B	18	18	18	5	EA	$105.00	B	III	

ACTION REQUESTED

23. AUTHORIZATION
☐ INCREASE ☐ ADD
☐ REDUCE ☐ DELETE

24. ISSUE/ DUE OUT ☐ ADVICE CODE
☐ INITIAL ISSUE ☐ CANCEL D/ O
☐ REPLACEMENT ISSUE

25. TURN-IN ☐
CONDITION
☐ SERVICEABLE ☐ REPARABLE
☒ CONDEMNED ☐ UNKNOWN
STATUS
☒ COMPLETE ☐ INCOMPLETE [1]

CALIBRATION REQUIRED YES ☐ NO ☒
CLEAN/ PAINT REQUIRED YES ☐ NO ☒
DISASSEMBLY REQUIRED YES ☐ NO ☒

17. BUDGET CODE | 18. ERRC

19. ITEM DESCRIPTION: Heater Structural Repair

20. CUSTODIAN SIGNATURE: Richard Kihn

21. TRANSACTION SERIAL NO.

22. JUSTIFICATION OR EXPLANATION OF REQUEST

1. Request that 5 (FIVE) EACH HEATER STRUCTURAL REPAIR, STOCK NUMBER 4430-00-789-2918, Be Requisitioned To Replace The Five That Have Been Condemned by Maintenance.

26. I certify that I have evaluated this request and the action requested herein is required.
SIGNATURE OF DISPN. POWER: Charles S. Latham
CHARLES S. LATHAM, GS-12
CHIEF, REPAIR

27. ACTION TAKEN BY EMO/ BEMO
APPROVED AS REQUESTED ☐
APPROVED AS INDICATED ☐
DISAPPROVED (See block 22) ☐
ADDITIONAL INFORMATION REQUIRED (See block 22) ☐

SIGNATURE/ BEMO/ EMO/ EAA

RECEIPT OF PROPERTY ACKNOWLEDGE (Signature - Receiving Custodian)

DATE AVAILABLE FOR PICK-UP: 5 Nov 75

28. BEMO/ EMO COMMENTS AND/ OR OTHER REVIEWING ACTIVITY COMMENTS

[1] Enter Missing Components in Block 22

1	2	3	4	5	6	7	8	9	10	11	12	13	14

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47

48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

AF FORM 601b APR 70 — PREVIOUS EDITION OF THIS FORM WILL BE USED. — CUSTODIAN REQUEST/ RECEIPT

Figure 3-9. AF Form 601b, Custodian Request/Receipt.

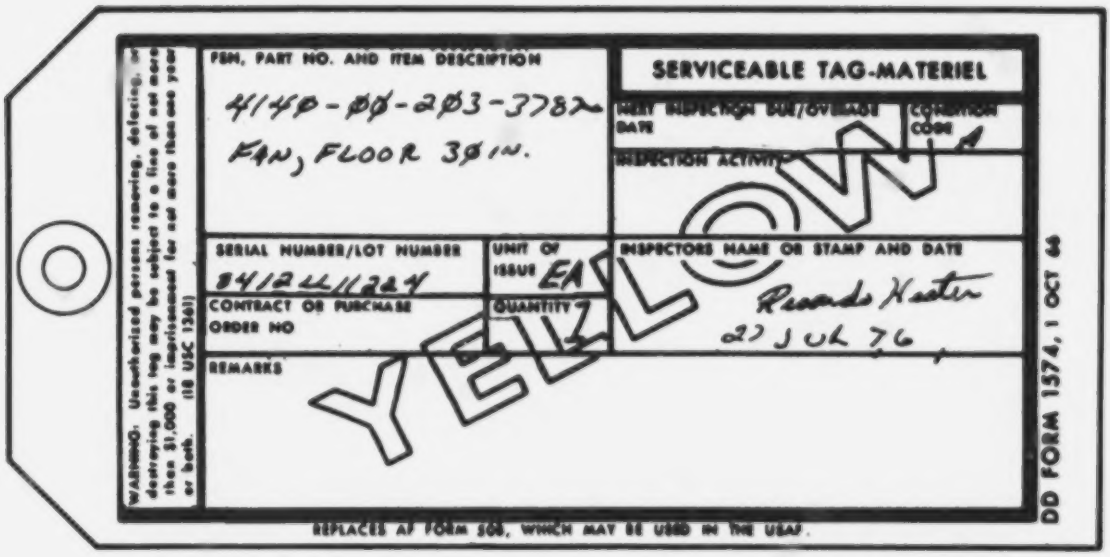

FSN, PART NO. AND ITEM DESCRIPTION
4140-00-203-3782
FAN, FLOOR 30 IN.
SERVICEABLE TAG-MATERIEL
NEXT INSPECTION DUE/OVERHAUL DATE
CONDITION CODE
A
INSPECTION ACTIVITY
SERIAL NUMBER/LOT NUMBER
841244 11224
UNIT OF ISSUE
EA
INSPECTORS NAME OR STAMP AND DATE
Ricardo Hester
27 JUL 76
CONTRACT OR PURCHASE ORDER NO
QUANTITY
REMARKS
YELLOW
WARNING: Unauthorized persons removing, defacing, or destroying this tag may be subject to a fine of not more than $1,000 or imprisonment for not more than one year or both. (18 USC 1361)
DD FORM 1574, 1 OCT 66
REPLACES AF FORM 508, WHICH MAY BE USED IN THE USAF.

Figure 3-10. DD Form 1574, Serviceable Tag—Materiel.

3-2. Shop Supplies and Equipment

044. State the purpose of shop bench stock and indicate the responsibilities for the initial recommendation, filling bins, and providing ample storage facilities.

How many different types of fasteners did you use today? Chances are you didn't have to order any because they were in the bench stock bins at the shop. Bench stock serves an important role in the day to day operation of your shop. Our discussion of supply during the next few objectives will be centered around in-house supply such as bench stock.

Bench Stock. The term "shop bench stock" applies to a group of low cost, expendable items which, due to repetitive consumption, are placed within a shop area. Bench stock supplies permit a smooth and orderly flow of work by having the normally used repair items, such as rivets and metal, on hand. This allows uninterrupted repairs and speeds up the return of repaired parts to their users.

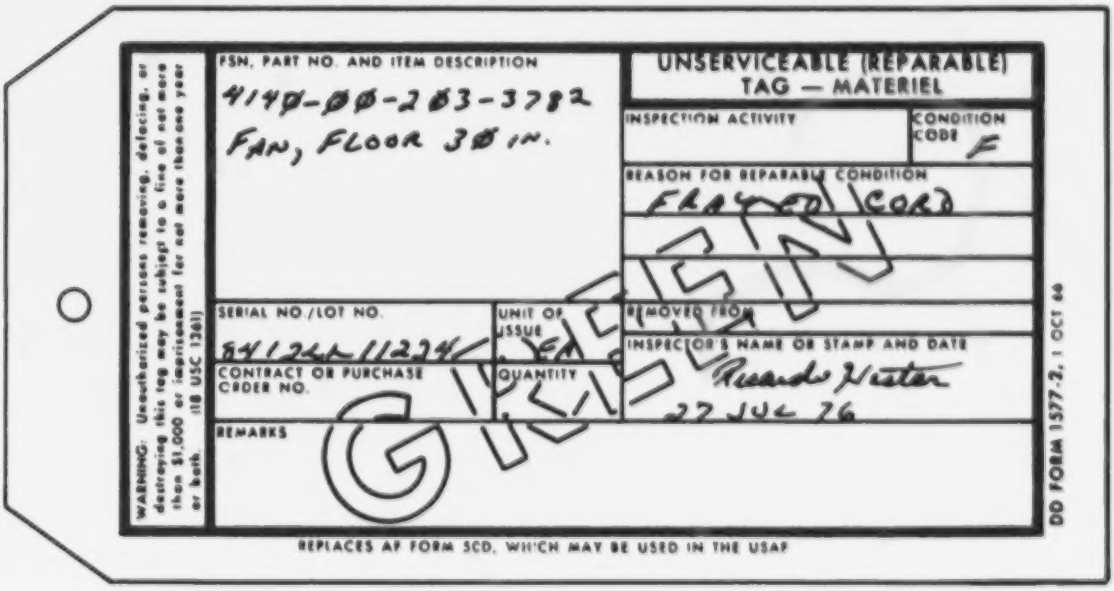

FSN, PART NO. AND ITEM DESCRIPTION
4140-00-203-3782
FAN, FLOOR 30 IN.
UNSERVICEABLE (REPARABLE) TAG — MATERIEL
INSPECTION ACTIVITY
CONDITION CODE
F
REASON FOR REPARABLE CONDITION
FRAYED CORD
SERIAL NO./LOT NO.
841244 11224
UNIT OF ISSUE
EA
REMOVED FROM
INSPECTOR'S NAME OR STAMP AND DATE
Ricardo Hester
27 JUL 76
CONTRACT OR PURCHASE ORDER NO.
QUANTITY
REMARKS
GREEN
WARNING: Unauthorized persons removing, defacing, or destroying this tag may be subject to a fine of not more than $1,000 or imprisonment for not more than one year or both. (18 USC 1361)
DD FORM 1577-2, 1 OCT 66
REPLACES AF FORM 5CD, WHICH MAY BE USED IN THE USAF

Figure 3-11. DD Form 1577-2, Unserviceable (Reparable) Tag—Materiel.

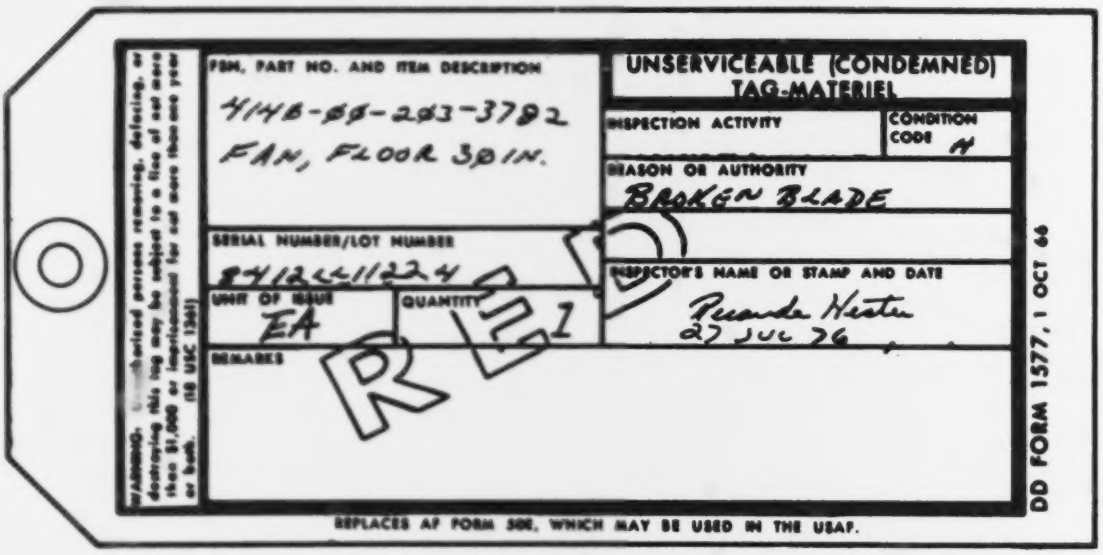


Figure 3-12. DD Form 1577, Unserviceable (Condemned) Tag—Materiel.

Ordering. Volume II of AFM 67-1 explains how to set up bench stock for the shop. It explains how to be sure that enough bits and pieces are always in the shop to meet the work schedule. The initial establishment of a bench stock is a coordinated effort between your shop and the Supplies Management Office (SMO). Bench stock requirements must be continually monitored to insure that only needed items are stocked. A change of aircraft for example, would require deletion and addition of items.

Bench stock levels are set up for an average 30-day requirement. Every week supply personnel review your bench stock to be sure you have enough items on hand. If your bench stock is low in some items, they are drawn from supply and placed in the assigned bins by supply people. If an out-of-stock condition occurs between the weekly walk-through, and there is not a due-out document in the bin, contact the bench stock service unit and request immediate replenishment action. If a due-out has already been established for the item and you urgently need the item, request the item from Deman Processing using normal issue procedures.

Storage of bench stock. The shop is responsible for providing adequate storage facilities for bench stock items, plus insuring proper care and conservation of bench stocks. Your responsibility is in the use of bench stock. When removing items from the bench stock, take only what you need and return the unused items to the correct bin. If you should remove all of an item, place an indicator (such as a colored tag) in the bin, so that the supply people will know the bin is empty and needs refilling.

Bin number identification. Each item approved for bench stock is assigned a 14-digit document number. This number is referred to as the item number and is used to identify the bin location as well as to serve as the supply document number for all supply actions (such as refilling or turn-in). Each item on bench stock retains the originally assigned number, even though the stock number is changed. Bench stock document numbers are constructed in the following format (left to right):

(1) Activity code—1 digit (always B).
(2) Organization code—3 digits.
(3) Shop code—2 digits.
(4) Date of last demand—4 digits (this will change each time there is a replenishment.
(5) Item number—4 digits (Bench stock items are binned in item number sequence.)

Exercises (044):

1. What is the purpose of a shop bench stock?

2. Who is responsible for filling the bench stock bins when supplies are received?

3. Who is responsible for providing ample storage space for bench stock?

4. What do you do if you have an urgent need for a bench stock item that has a due-out document in the bin?

045. Identify AFR 0-10 and cite the uses of TAs 503 and 783 and state the method of obtaining equipment for which no authorization exists.

So much for the bits and pieces required to operate the airframe repair shop. Now, how about tools and equipment? How do we get them?

Equipment and Tool Authorization Documents. Before an airframe repair shop can function properly to support its mission, not only sufficient manpower but also certain tools and equipment are needed. All the manpower could be available but, without equipment for the men to use, many tasks couldn't be accomplished. As a future supervisor, you must have a general understanding of authorization documents so that your workers will have the needed equipment and tools to complete their tasks.

AFR 0-10, Management Control and Authorization Program of Allowance Source Codes for USAF Activities. This index is a consolidated index of all USAF equipment allowance documents commonly known as table of allowances (TA). This AFR 0-10 is the first document to consult to locate a particular TA. A specific TA authorizes toolkits, general type shop tools, and equipment for an airframe repair shop.

Figure 3-13 is the first page of AFR 0-10. The TAs are indexed into specific sections within the regulation. Notice that Section B shows that all TAs numbered 401-650 fall into the category of facilities support. The TA for toolkits authorization (handtools) is in this category—TA 503.

TA 503. TA 503 is titled, *Air Force Technician Toolkits*, and it establishes the authorization for toolkits in each AFSC. In airframe repair, specialists use the same type of toolkit that the technician uses. The purpose

DEPARTMENT OF THE AIR FORCE
Headquarters, US Air Force
Washington DC 20330

AF REGULATION 0-10

Indexes

INDEX OF ALLOWANCE SOURCE CODES

This regulation provides a consolidated index of all USAF miscellaneous ASCs and current TAs. The approved utilization and application of TAs, as reflected in this regulation, is the authority for major commands to authorize acquisition and accountability of essential requirements. Approval for use of miscellaneous allowance source codes will be in accordance with AFM 67-1, volume IV, part one.

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Systems Support (251-400).....	6
Facilities Support (401-650).....	8
Personnel Support (651-700).....	15
Mission Support (701-930).....	15
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Tables of Allowance.....	22

1. When Revisions are Issued. Revisions of the index are issued in January, April, July, and October.

Change requests will pr detailed justification monitoring a

Figure 3-13. Index of Allowance Source Codes.

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS, UNITED STATES AIR FORCE

WASHINGTON

TA 783

TABLE OF ALLOWANCES BASIC 15 FEB 1974

SHEET METAL AND PLASTIC SHOPS (INTERMEDIATE MAINTENANCE)

*** THIS ISSUE REPLACES TA 783 DATED 15 FEB 1973 ***

PURPOSE

THIS ALLOWANCE DOCUMENT PRESCRIBES THE ESSENTIAL ITEMS OF EQUIPMENT NORMALLY REQUIRED FOR SUPPORT OF SHEET METAL AND PLASTIC SHOPS AND WILL BE USED AS THE ALLOWANCE SOURCE WHEN THE ITEMS LISTED HEREIN ARE AUTHORIZED AND INCLUDED ON MAJOR COMMAND ACCOUNTABLE RECORDS IN ACCORDANCE WITH VOLUME IV, AFM 67-1.

CHANGES TO THIS TABLE OF ALLOWANCE, I.E., INCREASES, REDUCTIONS TO THE BASIS OF ISSUE, PROPOSALS TO INCLUDE OTHER ITEMS IN A SEPARATE PART, SECTION, ETC., OR IN THE TA INITIALLY, WILL BE FORWARDED THROUGH THE COMMAND CEMO TO WRAMA/MMSE.

1. GENERAL INFORMATION

A. THE USE OF THIS TA IS RESTRICTED TO THE APPLICATION SHOWN HEREIN, AND IN AFR 0-10.

B. THE BASIS OF ISSUE REFLECTED IN THIS ALLOWANCE DOCUMENT, EXCEPT WHEN OTHERWISE SPECIFIED UNDER SPECIAL INFORMATION, REPRESENTS MAXIMUM ALLOWANCES FOR NONEXPENDABLE ITEMS. AUTHORIZATIONS WILL BE HELD TO MINIMUM ESSENTIAL TO ACCOMPLISH THE ASSIGNED MISSION/FUNCTION. MAXIMUM ALLOWANCES PRESCRIBED HEREIN WILL NOT BE AUTHORIZED UNLESS ESSENTIAL TO ACCOMPLISHMENT OF THE ASSIGNED FUNCTION OR MISSION.

C. THIS ALLOWANCE DOCUMENT WILL BE CITED AS THE ALLOWANCE SOURCE FOR LOCALLY MANUFACTURED NONEXPENDABLE ITEMS, WHEN SUCH ITEMS HAVE BEEN APPROVED BY THE EQUIPMENT REVIEW AND AUTHORIZATION ACTIVITY (ERAA) AS A VALID REQUIREMENT, FOR THE ACCOMPLISHMENT OF A REGULARLY ASSIGNED FUNCTION. THIS WILL NOT BE CONSTRUED AS AUTHORITY TO LOCALLY FABRICATE ITEMS OR SUBSTITUTES FOR ITEMS IN EXCESS OF THE BASIS OF ISSUE REFLECTED IN THE BODY OF THIS TA. THE PROVISIONS OF CHAPTER 18, VOLUME IV, PART ONE OF AFM 67-1 WILL BE FOLLOWED IN JUSTIFYING THE REQUIREMENT AND ACCOUNTING FOR LOCALLY MANUFACTURED EQUIPMENT TYPE ITEMS.

D. THIS ALLOWANCE DOCUMENT MAY BE CITED AS AUTHORITY TO REQUISITION AND ISSUE, IN ACCORDANCE WITH AFM 67-1, ANY ITEMS LISTED HEREIN WHICH ARE EXCLUDED FROM THE EAID IN ACCORDANCE WITH THE PROVISIONS OF VOLUME IV, AFM 67-1.

E. IT IS AIR FORCE POLICY TO NORMALLY PRESCRIBE HEREIN THE SUBGROUP MASTER ITEM OF THE INTERCHANGEABILITY AND SUBSTITUTE GROUP. THE MASTER ITEM OF THE I AND S GROUP IS PRESCRIBED WHEN THE FULL CAPABILITY OF THE ITEM IS REQUIRED. SUITABLE SUBSTITUTES OF THE I AND S GROUP MAY BE USED IN LIEU OF THOSE PRESCRIBED UNTIL NO LONGER ECONOMICALLY REPAIRABLE.

F. EXPENDABLE ITEMS PRESCRIBED HEREIN ARE LISTED TO PROVIDE INFORMATION TO USING ACTIVITIES. IT IS THE PREOGATIVE OF THE USING COMMAND TO CHANGE THESE ITEMS AND QUANTITIES WHEN REQUIRED.

G. THE UNIT OF ISSUE FOR ITEMS PRESCRIBED HEREIN IS EACH, UNLESS OTHERWISE INDICATED OR AS NOTED IN THE FEDERAL STOCK CATALOG.

H. ITEMS PRESCRIBED IN THIS DOCUMENT WHICH HAVE MORE THAN ONE MAKE OR MODEL ARE LISTED UNDER THE BASIC FEDERAL STOCK NUMBER, OF THE AUTHORIZATION AND PROCUREMENT (JCA CODED) STOCK NUMBER. FOR SPECIFIC MAKE OR MODEL REFER TO THE APPLICABLE FEDERAL STOCK LIST OR TO THE MASTER EQUIPMENT MANAGEMENT INDEX (MEMI).

I. PENDING REVISION OF THIS TA, REFER TO TA 001 (MEMI) FOR UPDATE (ADDITIVE OR DELETION) OF STOCK NUMBERS LISTED HEREIN.

J. ACTION CODES ARE REFLECTED TO THE LEFT OF THE BASIS OF ISSUE COLUMN(S) FOR THE ITEMS WHICH HAVE BEEN CHANGED IN THIS PUBLICATION. THE FOLLOWING ALPHA CODES WILL BE USED TO DENOTE THE TYPE OF CHANGE.

(1) A - ADDED ITEM.

(2) C - CHANGE IN BASIS OF ISSUE.

(3) D - DELETED ITEM (TOTAL LINE ITEM).

K. REASONS FOR DISCONTINUANCE OF A STOCK NUMBER IN THIS TA ARE CODED AS FOLLOWS.

(1) STOCK NUMBER REIDENTIFIED. OLD STOCK NUMBER WILL SHOW THE PHRASE, CHANGED TO SN XXXX-XXX-XXXX. NEW STOCK NUMBER WILL SHOW THE PHRASE, CHANGED FROM SN XXXX-XXX-XXXX.

(2) ALLOWANCE CHANGED TO A DIFFERENT ITEM. OLD STOCK NUMBER ITEM WILL SHOW THE PHRASE, REPLACED BY SN XXXX-XXX-XXXX. NEW STOCK NUMBERED ITEM WILL SHOW THE PHRASE, REPLACES SN XXXX-XXX-XXXX.

(3) DELETED ALLOWANCES. WHEN AN ITEM AND ITS ALLOWANCES ARE WITHDRAWN FROM THIS TA, THE PHRASE, DELETED, WILL APPEAR.

(4) TRANSFER OF AN ITEM AND ITS ALLOWANCES TO A DIFFERENT TA. WHEN AN ITEM IS TRANSFERRING TO A DIFFERENT TA, THE ITEM WILL REFLECT THE PHRASE, TRANSFERRED TO TA XXX. UPON INCLUSION OF THE ITEM IN THE

Figure 3-14. TA 783.

ORGANIZATIONAL ITEM LIST

SUB-DIV A CONTINUED

STOCK NUMBER / NOMENCLATURE	NOTE CODES	EQ CD	ACT	BASIS OF ISSUE COL	
3445-263-0093 SHEARING MACHINE METAL SQUARING FOOT OPERATED 18 GAGE THK METAL CAPACITY 96 IN CUTTING LG 18 IN BACK GAGE RANGE 46 IN FRONT GAGE RANGE NIAGRA MACHINE AND TOOL WORKS MODEL 196F				A 1	
3445-263-0105 SHEARING MACHINE, THROATLESS, ROTARY , FLOOR MTG. 12 GA. CAP., 4 IN. RAD				A 1	
3445-266-9574 PUNCHING & SHEARING MACHINE,METAL, POWER DRIVEN,FLOOR MTD,MODEL 1/2			C	1	AUTH PACAFT HICKAM AFB ONLY
3445-490-9620 SHEARING MACHINE METAL SLITTING ROTARY BENCH MTG 1-5/8 IN DIA CUTTERS 20 GA CAP				A 1	
3445-729-4065 SHEARING MACH METAL SQUARING POWER OPER FED 00-S-305A TYPE II CLASS C OR EQUAL (NOTE - OR FSN 3445-809-1974)				A 1	
3445-809-1974 SHEARING MACHINE-METAL SQUARING 15 HP 220/440V AC 3/8 IN THK 12 FT CUT FED 00-S-305 TYPE 22 CLASS D					SEE FSN 3445-729-4065 FOR ALLOWANCE
3445-812-5212 PUNCH & SHEAR MACH, METAL, POWER DR MOD R41P			C	1	AUTH 3211TH INTERMEDIATE MAINT SQ EGLIN AFB
3445-861-1058 SHEARING MACHINE,SHEET METAL COMB. FLOOR MTD,49-1/4 IN. THROAT D,220-440V,AC,60CYC,3PH,1/4 IN. MILD STEEL P/N TE-250				A 1 1	ADDL AUTH 3211TH INTERMEDIATE MAINT SQ EGLIN AFB
3445-879-1352 PUNCHING AND SHEARING MACH METAL POWER OPER 1/2 IN DIA 15 IN THROAT			C	1	AUTH PATRICK AFB
3446-243-2665 HAMMER BUMPING POWER VERT FLOOR MTD 36 INCH				A 1	
3446-528-1922 SWAGING MACHINE, ROTARY, ELECTRIC FLOOR MTG			C	1	AUTH MAC BASES PERFORMING SHEET METAL PLASTIC FIBER-GLASS AND/OR REINFORCED PLASTIC PANEL REPAIRS ON C-141/C-5 ACFT
3446-596-7470 SWAGING MACH ROTARY ELEC P/N 3-1/2A			C	1	AUTH GRIFFIS AFB ONLY
3448-586-1017 DIMPLING MACH STATIONARY HOT AND COL D PROCESS				A 1	
3449-528-1897 STITCHER METAL FL MTD FT OPRT 25 IN THROAT DEPTH			C	1	AUTH TO ACTY ASSIGNED ACFT POWERED BY RECIPROCATING TYPE ENGINES
3693-493-0203 MACHINE PRESETTING				A 1	
3950-641-6201 CRANE FLOOR PORTABLE 6 FT 3 IN HIGH 2000 LB CAPACITY			C	1	AUTH ONLY TO THOSE ACTIVITIES NOT HAVING OVER-HEAD CRANE FACILITIES

READ THE PREFACE AND NOTES

Figure 3-15. TA 783, Organization item list.

STATEMENT OF CHARGES FOR GOVERNMENT PROPERTY LOST, DAMAGED OR DESTROYED

MILITARY PAY ORDER NUMBER: —

DATE: 30 Nov 76

CLASS OF PROPERTY: AIR FORCE (SE)

ORGANIZATION: 370th Bomb Sq (M)

FOR MONTH OF: November

STOCK RECORD ACCOUNT OR OTHER PROPERTY RECORD OF ACCOUNTABLE OFFICER: EAID No. 370391750000

STATION: Kincheloe AFB, MI

STOCK NO.	ARTICLES	QUANTITIES 1	2	3	4	5	6	7	TOTAL ARTICLES	UNIT PRICE	TOTAL
7210-00-160-0375	Comforter, Bed		1		1				2	$10.40	$20.80
7210-00-221-0352	Blanket	1							1	8.05	8.05
7210-00-527-6089	Cover, Mattress	1		1	1				3	3.00	9.00
	*Depreciation computed at 25%										
									GRAND TOTAL		$37.85

CERTIFICATE OF RESPONSIBLE INDIVIDUALS

I certify that my signature hereon consititues:

a. An authorization to recover the amount of indebtness by payroll deduction.

b. An affirmation that the articles are not now in my possession.

c. An agreement to turn in to the appropriate supply officer all articles later recovered, it being understood that the United States Government retains title to the articles listed hereon.

COL NO.	NAME, GRADE AND SOCIAL SECURITY NUMBER	CAUSE FOR CHARGE	TOTAL CHARGE	SIGNATURE OF INDIVIDUAL & AMOUNT ACCEPTED — SIGNATURE	AMOUNT ACCEPTED
1	NAME Francis L. Fisher GRADE Sgt SSN 401-54-1095	Lost thru neglect	$8.29	Francis L Fisher	
2	NAME James A. Anketelle GRADE SSgt SSN 326-26-1728	Lost thru neglect	7.80	James A Anketelle	
3	NAME Richard G. Jannis GRADE Amn SSN 262-62-1348	Lost thru neglect	2.25	Richard G Jannis	
4	NAME Jack P. Delano GRADE Sgt SSN 248-61-7798	Destroyed thru carelessness	10.05	Jack P. Delano	
5	NAME GRADE SSN				
6	NAME GRADE SSN				
7	NAME GRADE SSN				
	GRAND TOTAL		28.39		

ORGANIZATION COMMANDER

The statements hereon are complete and correct, all damaged property has been disposed of in accordance with current directives and the charges have been computed in accordance with the provisions of AR 735-11 *(AFM 67-1 for USAF)*.

DATE: 3 Dec 76

SIGNATURE: Colbert B. Watkins
Colbert B. Watkins
Lt Col, USAF Commander

DISBURSING OFFICER OR PAYROLL CERTIFYING OFFICER

The charge set opposite the name of each person listed hereon has been entered on the appropriate pay record or payroll, or DD Form 139 has been prepared and forwarded for collection.

DATE: 5 Dec 76

SIGNATURE: Roy M. Meredith
Roy M. Meredith, 1Lt, USAF

PROPERTY VOUCHER NUMBER: —

DD FORM 1 MAR 74 362

REPLACES DD FORM 362, 1 SEP 69, WHICH MAY BE USED UNTIL EXHAUSTED.

Figure 3-16. DD Form 362, Statement of Charges.

CASH COLLECTION VOUCHER

DISBURSING OFFICE COLLECTION VOUCHER NUMBER

RECEIVING OFFICE COLLECTION VOUCHER NUMBER
355-00246

RECEIVING OFFICE

ACTIVITY (Name and location)
Department of the Air Force, EMO, Winter AFB, Utah

RECEIVED AND FORWARDED BY (Printed name, title and signature)
Henry J. Smith
Henry J. Smith, Lt Col, USAF
Chief, EMO

DATE
3 Jul 1976

DISBURSING OFFICE

ACTIVITY (Name and location)
Accounting and Finance Officer, Winter AFB, Utah

DISBURSING OFFICER (Printed name, title and signature)
Marvin R. Herrin
Marvin R. Herrin, Major, USAF
Accounting and Finance SN B4436

DISBURSING STATION SYMBOL NUMBER
G75-0827695

DATE RECEIVED SUBJECT TO COLLECTION

PERIOD: From 1 July 1976 To 31 July 1976

DATE RECEIVED	NAME OF REMITTER DESCRIPTION OF REMITTANCE	DETAILED DESCRIPTION OF PURPOSE FOR WHICH COLLECTIONS WERE RECEIVED	AMOUNT	ACCOUNTING CLASSIFICATION
	Jack C. Hanson SSgt, USAF FR 401-54-1558	1 Each 7110-00-266-7444 CASE, Mail distribution, portable, folding type, wood top and bottom, aluminum frame, cotton duct partitions. UNIT PRICE $12.50 (Lost through neglect)	$12.50	
	Ivan B. Cooper Sgt, USAF, FR262-62-2124	1 Each 7110-00-132-6648 BLACKBOARD, Stand type, double face, reversible, black slate, 3' x 3' with erasure trough. UNIT PRICE $10.50 (Damaged beyond economical repair through carelessness)	$10.50	
		USED IN LIEU OF REPORT OF SURVEY (Support Equipment)		
		Approved: Henry G. Sampson, Major, USAF Commander 449th Bomb Squadron (M)		
		Depreciation is not authorized.		
		TOTAL	$23.00	

DD FORM APR 57 1131 PREVIOUS EDITION MAY BE USED.

42-352

Form approved by Comptroller General, U.S. 24 January 1956

Figure 3-17. DD Form 1131, Cash Collection Voucher.

REPORT OF SURVEY

1. DATE: 4 Nov 1976
2. SURVEY NUMBER:

3. CLASS OF PROPERTY: Air Force, Individual
4. STOCK RECORD ACCOUNT OR OTHER PROPERTY RECORD AND STATION: 370 Bomb Wing (M), Winter AFB, Utah

5. ACCOUNTABLE OR RESPONSIBLE OFFICER (Name, grade, SSN and designation): Larry J. Lebbans, Lt Col USAF, 243-68-3124, Chief EMO, Winter AFB, Utah

6. NATIONAL STOCK NUMBER	7. DESCRIPTION	8. QUANTITY	9. UNIT PRICE	10. TOTAL COST	11. DISPOSITION
8415-00-268-7763	Jacket, flying, man's Type B-15D, Size 44	1 ea	15.00	$15.00	
	GRAND TOTAL			15.00	

RECOMMENDED PECUNIARY CHARGE → 12. FOR LOSS: | 13. FOR DAMAGE:

14. DATE AND CIRCUMSTANCES

On October 18th item was issued on AF Form 538, Personal Clothing and Equipment Record, to TSgt Jack L. Vance, FR100-21-3843. On November 3rd TSgt Vance reported the loss of subject item to me and to the Director of Security and Law Enforcement. He stated that the item was removed from the coat rack in Dining Hall Nr 2 during the dinner meal on November 3rd by a person, or persons unknown.

See Exhibits "A" and "B" attached.

15. **AFFIDAVIT**

I do solemnly swear (or affirm) that (to the best of my knowledge and belief) the articles of public property shown above and/or on attached sheets were lost, destroyed, damaged, or worn out in the manner stated, while in the public service.

SIGNATURE: Larry J. Lebbans

NAME, GRADE, SSN AND ORGANIZATION: Lt Col, USAF, 243-68-3124, Chief, EMO, 370th M&S Group

SUBSCRIBED AND SWORN TO (or affirmed) BEFORE ME AT Winter AFB, Utah THIS 4th DAY OF November 19 76

SIGNATURE:

NAME, GRADE, SSN AND ORGANIZATION OR TITLE; IF NOTARY PUBLIC, AFFIX SEAL: DAS, 370th Bomb Wg (M) Authorized to administer oaths & act as notary 10 USC 936 & AFR 20-16

16. **CERTIFICATE**

I certify that the loss, destruction, damage, or unserviceability of the articles of public property shown above, and/or on attached sheets, was caused in the manner stated and without fault or neglect on my part, and that each article listed with a view to elimination by destruction has been examined by me personally, has never been previously condemned, and is, in my opinion, worthless for further public use.

SIGNATURE (Accountable or Responsible Officer):

NAME, GRADE, SSN AND ORGANIZATION:

17. HEADQUARTERS

STATION | DATE

TO

YOU ARE APPOINTED SURVEYING OFFICER

BY ORDER OF

SIGNATURE OF ADJUTANT/EXECUTIVE OFFICER & DATE

18. THIS SPACE RESERVED FOR ACTION BY AUTHORITY OF:

19. PROPERTY VOUCHER NUMBER

DD FORM 1 DEC 73 200 PREVIOUS EDITION WILL BE USED.

Figure 3-18. DD Form 200, Report of Survey.

of this TA is to prescribe essential handtools required to perform duties as outlined in the AFSCs listed in AFM 39-1.

The TA contains a list of almost every basic type and size of common tool that you will ever use. The basis of issue is one each. However, there is one exception to this. When more than one identical tool is required, the organizational commander may request that the required quantity be issued.

TA 783. Refer again to figure 3-13, Section B. Notice that TAs listed in AFR 0-10 numbered 701-930 are classed in the category of mission support. An airframe repair shop falls within this category. Figure 3-14 shows the cover page for TA 783, Sheet Metal and Plastic Shops (Intermediate Maintenance), which provides the authority for the equipment and tools for the operation of an airframe repair shop.

Figure 3-15 is an extract of part A of TA 783. Notice that a Dimpling Machine, Stationary Hot or Cold Process, is listed with a basic issue of A1. This does not imply that you cannot have two or three dimples in the shop. If you require more, justification is submitted for the required increase. TAs set the basic allowance, but individual situations dictate the actual amount needed.

The discussion in the preceding paragraphs concerns the "how"to find what authorizations already existed. Another problem that sometimes faces the shop supervisor is the need for equipment that has not been authorized. In this case, he must coordinate with Material Control to substantiate that need and then acquire the equipment.

AFM 66-1 requires that equipment authorizations be continually reviewed and compared against current work requirements. The word "current" is the key word to be emphasized. Work requirements do not necessarily remain constant. Equipment that one shop doesn't need might be needed by another shop. This is why it is important to turn in excess equipment as soon as possible.

Exercises (045):

1. What comprises AFR 0-10?

2. When would you consult TA 502?

3. When would you consult TA 783?

4. If no authorization exists for equipment and tools needed to support the mission, how can you go about obtaining this equipment?

3-3. Supply Supervision

Supply supervision deals with accountability and responsibility for issued supplies. Liability is also a part of supervision. According to AFR 67-10, "Pecuniary liability may be shared in any particular case by persons having command, supervisory, and custodial responsibility." This means you may have to help pay for something damaged or lost if you are the responsible person's supervisor. Because of this liability there are some areas that we should discuss.

046. Indicate the difference between accountability, and responsibility for supplies and equipment.

Air Force Regulation 67-10, *Responsibility for Management of Public Property in Possession of the Air Force,* states the policies regarding responsibility for property under the control of the Air Force. Remember that you are responsible for the property under your control. Along with responsibility, there is accountability, and both are very important parts of supply discipline.

The following definitions have been taken from AFR 67-10 to help you understand accountability and responsibility.

Property Accountability. Accountability is the obligation imposed by law or lawful order or regulation on an individual for keeping accurate records of property or funds. The person having this obligation may or may not have actual possession of the property or funds. Accountability is concerned primarily with records, while responsibility is concerned primarily with custody, care, and safekeeping.

Property Responsibility. Property responsibility is the obligation of an individual for the proper care of all property under the control of the Air Force, whether he receipted for it or not and whether or not it was issued to his care, custody, or use. Such responsibility includes pecuniary liability. Property responsibility is in no way lessened if accountbility for the property has been terminated by the issuing authority, or the individual is not responsible for or is not associated with a numbered or nonnumbered record account.

Responsible Individual. The responsible individual is anyone who has property responsibility. You can see very readily that even if you are not accountable for supplies, you are still responsible for them.

Exercises (046):

1. SSgt Jones is custodian for a special tool account from which you borrow a tool and lose it. Who is responsible for the tool?

2. In the above situation, who is accountable for the tool?

3. Who is responsible for the care of shop equipment?

047. Define the terms "property responsibility" and "supervisory responsibility," and cite key factors related to the Air Force collection methods when pecuniary liability is admitted.

To understand the use of the statement of charges, study the definitions of "Property Responsibility" and "Supervisory Responsibility."

Property Responsibility. The property you use in the completion of your work is your responsibility, even if its accountability lies with someone else. Each member of the Air Force is responsible for the use, care, and safeguarding of Air Force property.

Supervisory Responsibility. Supervisory responsibility applies to any person who exercises supervision over property received, in use, in transit, in storage, or undergoing modification or repair. This means that you, as a supervisor, along with the responsible person, can be held financially responsible and made to pay for property that was lost, damaged, or destroyed (pecuniary liability). If you are liable, you must pay, and the Air Force has two methods of collection: by Statement of Charges or by Cash Collection Voucher.

A Statement of Charges for Government Property Lost, Damaged, or Destroyed, DD Form 362 (fig. 3-16), is used when a person admits pecuniary liability for an item but doesn't have the cash to pay for it. The responsible individual must sign the form to authorize payroll deduction. The form is also signed by his organization commander. If the responsible individual desires to pay cash, a Cash Collection Voucher, DD Form 1131 (fig. 3-17), is used. Either form may be used if the individual admits pecuniary liability. However, if he does not admit pecuniary liability, a Report of Survey, to be discussed in our next objective, must be completed.

Exercises (047):

1. What is meant by the term property responsibility?

2. What is meant by the term supervisory responsibility?

3. When is a DD Form 362 used?

4. When is a DD Form 1131 used?

048. Identify a Report of Survey as to the form number, use, and resulting action.

A Report of Survey, DD Form 200, is illustrated in figure 3-18. A Report of Survey must be completed when pecuniary liability is not admitted. This form is an instrument for explaining and recording the circumstances surrounding the loss, damage, or destruction of Air Force property. The Report of Survey resolves questions of responsibility for the loss and fixes the pecuniary liability upon a person, persons, firm, or corporation. The DD Form 200 must be initiated immediately after it is known that loss, damage, or destruction of property has occurred and no one will admit liability. The Report of Survey must be signed by the person who had control of the property at the time of the loss, damage, or destruction. It must also be signed by the accountable officer. Upon the completion of the Report of Survey, one of two things occurs. It either supports dropping the property from the records, or it finds a person or persons liable for the loss, damage, or destruction of the property. If a person's liability is established, he must reimburse the Air Force by using a Cash Collection Voucher or a Statement of Charges, as we have already described.

Exercises (048):

1. What is the form number for a Report of Survey?

2. When is a Report of Survey initiated?

3. If a Report of Survey finds a person liable for the loss of the property, what action must be taken?

4. How can the responsible person reimburse the Air Force?

CHAPTER 4

Maintenance Management

THE AIR FORCE, like any business organization, consists of equipment, facilities, and people. The efficient use of this manpower and equipment is what maintenance management is all about. You, as an airframe repairman, are an important part of the Air Force's maintenance team, and the goals of maintenance management should be your goals.

In this chapter, we will deal primarily with how you and your shop fit into the maintenance team. As we progress, the policies, procedures, and various maintenance systems that are used daily in the maintenance of Air Force resources will be discussed. Air Force Manual 66–1, *Maintenance Management,* establishes the maintenance management system, which is used in all Air Force activities engaged in the maintenance of equipment.

Most of the policies and procedures outlines in AFM 66–1 can be adapted to every maintenance activity. However, it must be remembered that the maintenance organization structure will vary somewhat with the size of the organization and assigned mission requirements.

4-1. Organization and Functions

In taking an overall look at an organization, the place to start is at the top position. It is from this position that the "pulse" of an organization originates. How good or bad an outfit performs can be directly traced to this individual. This is why the Air Force selects only the most highly qualified individual for the title of Chief of Maintenance. NOTE: Many bases use the title "Deputy Director for Maintenance" in place of "Chief of Maintenance." Since the usage is not standard, we use the more familiar term, "Chief of Maintenance," in this discussion.

049. State the qualifications and responsibilities of the Chief of Maintenance.

Chief of Maintenance. The Chief of Maintenance must be highly qualified in leadership, management, and administration, because the aircraft maintenance organization of one wing is larger and more complex than the operation of many commercial companies. The Chief of Maintenance is a position established at the highest level of operational control, and the person who occupies this position is usually the senior and is always the most qualified maintenance officer in the organization. He is the executive manager of his maintenance organization, and he exercises centralized control and direction of all functions of the activity.

Through staff agencies provided for his use as assistants: the Chief of Maintenance manages, plans, controls, executes, and produces the work needed to fulfill his functional responsibility. The staff agencies act in the name of the Chief of Maintenance on those matters for which they have been given responsibility. He and his staff must provide the direction and guidance essential for all subordinates to implement, apply, and comply with local and higher headquarters directives.

Exercises (049):

1. What are some of the qualifications for becoming a Chief of Maintenance?

2. List the functional responsibilities of the Chief of Maintenance.

3. What must the Chief of Maintenance and his staff provide subordinates to have an effective maintenance team?

050. Name the sections of the Maintenance Control Branch, and identify the duties and responsibilities related to the agencies within the branch.

As previously mentioned, the Chief of Maintenance has staff agencies that work directly for him. These agencies help the Chief of Maintenance to plan, control, coordinate, and execute his responsibilities as the maintenance manager. Figure 4-1 illustrates this organizational structure. For purposes of discussion, the staff agencies are grouped into three interdependent

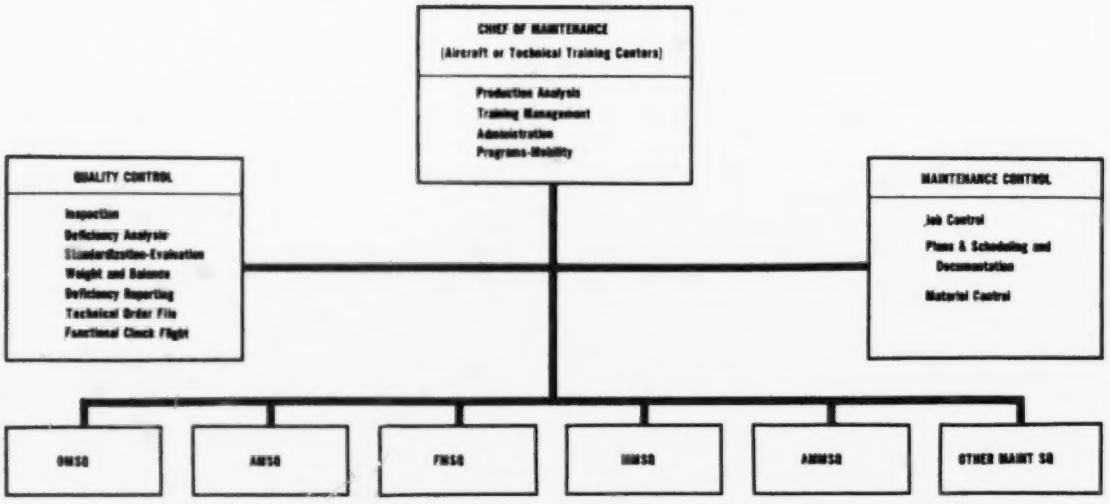

Figure 4-1. Organizational Chart for the Chief of Maintenance.

branches: the Maintenance Control Branch, the Quality Control Branch, and the Management Support Branch (shown in figure 4-1 only as its separate offices directly under the Chief of Maintenance). The first one we'll look into is the Maintenance Control Branch. This is the one which you'll have the most direct contact with.

Maintenance Control Branch. Maintenance Control is the staff function responsible for directing the maintenance production activity, authorizing the expenditure of resources, and controlling the action required to support the mission. To carry out these responsibilities, Maintenace Control is divided into three functional sections: Job Control, Plans and Scheduling and Documentation, and Materiel Control.

Job Control. Job Control is responsible for the implementation of maintenance plans and the control of maintenance resources to meet the assigned mission requirements. Job Control monitors all maintenance being performed in the maintenance complex. Some of the duties of Job Control are as follows:

a. Maintain visual aids showing the status of each aerospace vehicle on station that is being maintained by the maintenance complex.

b. Authorize and assign work priorities, start and completion times for unscheduled maintenance.

c. Control all maintenance on assigned aerospace vehicles and equipment.

d. Supervise and control the maintenance communication systems to provide an effective transmission of information and movement of materiel and maintenance personnel.

Your contact with Job Control is extensive in the performance of your work on the flight line. Flight-line work orders are relayed to the shop from Job Control. Transportation requests to and from the job site are handled through Job Control. If you should need AGE equipment, Job Control will contact the AGE dispatcher for quick delivery of the equipment, and lastly, when you finish your job, Job Control is notified. From start to finish Job Control monitors your progress in accomplishing your work.

Plans and Scheduling and Documentation. Your contact with this agency is not as direct as it was with Job Control, but its functions have a bearing on the work you might be doing.

Some of the duties of Plans and Scheduling and Documentation are as follows:

a. Forecast and monitor long-range requirements (inspections, flying hours, training exercises, etc.).

b. Develop and publish unit maintenance plans.

c. Review, evaluate, and file information essential to the planning and scheduling of maintenance action.

d. Maintain historical data.

e. Check AFTO Form 781 series for accuracy and validity.

The area that effects you the most is in the scheduling of scheduled maintenance. Scheduled maintenance consists of dock or phase inspections, TCTO due dates, and completion of delayed maintenance work.

Materiel Control. The first two agencies dealt mostly with flight-line work. This agency, as far as an airframe shop is concerned, is related to in-shop work procedures. The monitoring and controlling of repair items in the shop is just as important as is work performed on the flight line.

Materiel Control Branch has the responsibility of managing both supply transactions and repairing of items in the repair cycle. These two functions are han-

dled through two subdivisions of the branch—Production Control and Maintenance Supply Liaison (MSL). Production Control is responsible for two interrelated functions, shop scheduling and operating a reparable processing center (RPC). Repair items are monitored, controlled, and scheduled by RPC into the various maintenance shops on a timely basis. Requests for locally manufactured items are also handled through Production Control.

MSL is primarily responsible for management of maintenance supply actions and providing assistance to maintenance personnel who have supply problems. MSL also coordinates with base supply in establishing a system for obtaining authorization for parts, tools, and equipment, when required.

Exercises (050):

1. What are the three sections of the Maintenance Control Branch?

2. In the space provided in front of each of the following items, place the title of the section in the Maintenance Control Branch to which the duty or responsibility belongs.
   _____ a. Works closely with supply.
   _____ b. Maintains historical data.
   _____ c. Monitors all maintenance activities.
   _____ d. Programs scheduled maintenance.
   _____ e. Processes reparable items.
   _____ f. Controls maintenance communication systems.
   _____ g. Develops maintenance preplans.
   _____ h. Assists in obtaining authorization for tools and equipment.
   _____ i. Checks accuracy and validity of aircraft forms.
   _____ j. Processes requests for local manufacturing of items.

051. Name the subdivided sections of the Quality Control Branch, and identify the duties and responsibilities related to agencies within the branch.

Quality Control Branch. The Quality Control Branch is responsible for assuring that quality maintenance is performed throughout the maintenance organization. Quality Control must assure that technical and management procedures prescribed for use in the production functions are followed. You will come in contact with Quality Control personnel everyday, either while working in the shop or on the flight line. They insure that your work area is as safe as possible, that methods and procedures being used to accomplish maintenance are the correct ones, and that the finished jobs meet the standards of acceptability.

To fulfill these responsibilities, the Quality Control Branch is subdivided into seven sections. They are: (a) inspection, (b) deficiency analysis, (c) standardization-evaluation, (d) weight and balance, (e) technical order library, (f) functional check flight and (g) deficiency reporting. We'll briefly discuss some of the duties and responsibilities of each of these sections and see how each fits in the maintenance complex.

Inspection. The inspection function determines the quality of maintenance by performing inspections of all maintenance activities and staff functions at least twice a year. Further checks are made by performing spot and followup inspections.

Deficiency Analysis. Deficiency Analysis performs the technical investigation and troubleshooting phase of the problem analysis process. Therefore, they must maintain a close working relationship with production analysis and the inspection function of Quality Control. Some of the responsibilities of Deficiency Analysis are given below.

- Analyze referrals initiated by maintenance activities.
- Develop and maintain job standards in coordination with other maintenance functions.
- Recommend improvements to equipment utilization, procedures, work environment, and manpower utilization.
- Analyze the maintenance standardization evaluation reports and man-hour consumption reports, and review inspection reports to determine trends and areas for further investigation.

Deficiency Reporting. Closely related to Deficiency Analysis is the deficiency reporting function.

Some of the minimum duties of the deficiency reporting function are as follows:

- Process and control technical order improvement reports and deficiency reports.
- Insure compliance with technical order procedures for aircraft returning from depot or contact overhaul.
- Maintain the necessary data required for materiel and publication deficiency studies.
- Distribute corrective action information on these deficiency reports and inform the Chief of Maintenance of all unsatisfactory materiel reports submitted on assigned equipment.

Maintenance Standardization and Evaluation (MSEP): The objective of maintenance standardization is to improve maintenance quality and capability and improve competence of mechanics and technicians. Through the use of Quality Control, MSEP encourages maintenance personnel to use standard maintenance practices and comply strictly with accurate technical data. Periodically, this function evaluates maintenance personnel and equipment with highly qualified technicians.

The MSEP is administered at unit level. This permits the Chief of Maintenance to focus attention on

the problems that need improvement. Point values and objective ratings are assigned to various areas to be rated. The MSEP gives the Chief of Maintenance an excellent tool for finding weak areas in his organization and with the means to correct them. Here is an example: Personnel evaluation finds unqualified personnel assigned to perform a certain task. These persons, thus pinpointed, are singled out for further training or other corrective measures prescribed.

Weight and Balance. The aircraft quality control supervisor serves as the unit weight and balance officer. He is responsible for compliance with appropriate technical order procedures for weighing aircraft and for maintaining the required documents. Preparation, jacking, and weighing of the aircraft will be accomplished by organizational maintenance or repair and reclamation personnel under the supervision of Quality Control weight and balance personnel. Quality Control personnel will verify scale readings and perform the actual computations.

Technical Order Library. Quality Control is responsible for maintaining an up-to-date technical order file. This includes inspection workcards, work unit code manuals, and checklists.

Modifications frequently require changes to technical orders. Each time compliance technical order (TCTO) lists the affected technical orders that must be changed as a result of the modification. Quality Control must insure that all replaced and changed pages are retained in the central file until the modification has been completely complied with by their organization.

Quality Control also inspects in-use technical orders during technical inspections to be sure that they are serviceable and up to-date.

When revisions are necessary for any of the in-use files throughout the maintenance complex. Quality Control advises all affected activities.

When technical orders have not been published for equipment assigned to the maintenance complex, Quality Control may establish a file of commercial publications relating to this equipment as authorized in AFR 8-2, *Air Force Technical Order (TO) System,* and TO 00-5-1.

Functional Check Flight. When certain types of maintenance have been performed on aircraft, it is a technical order requirement that the aircraft be given a functional check flight. Quality Control is assigned this function. The various commanders must submit to the Functional Check Flight function of Quality Control, in writing, the crews authorized to test assigned aircraft.

The Functional Check Flight section has two important responsibilities. The first and most important is to assure that assigned aircraft are safe for flight. This is accomplished through inspection and functional testing of aircraft in flight. The second is to accurately determine and report the quality of maintenance performed by the maintenance organization.

Exercises (051):

1. What are the subdivided sections of the Quality Control Branch?

2. In the space provided in front of each of the following items, place the title of the subdivided sections in the Quality Control Branch to which the duty or responsibility belongs.

_____ *a.* Recommends improvement in manpower utilization.
_____ *b.* Performs spot checks related to quality of maintenance.
_____ *c.* Insures compliance with technical order procedures for aircraft returning from depot or contract overhaul.
_____ *d.* Excellent tool for finding weak areas.
_____ *e.* Develops and maintains job standards.
_____ *f.* Assures that assigned aircraft are safe for flight.
_____ *g.* Establishes a file of commercial publications.
_____ *h.* Responsible for compliance with technical order procedures for jacking aircraft.

052. Identify the duties and responsibilities associated with the sections that comprise the Management Support Branch.

Management Support Branch. The first two branches dealt directly with the maintenance being accomplished. The Management Support Branch deals only indirectly with the actual performance of maintenance. They handle the enormous amount of paperwork generated in the operation of a maintenance complex. This does not lessen their importance in the overall maintenance complex, as you'll see from the discussion of each of its sections.

Administration. Administration is the administrative management center of the maintenance complex and the focal point for all correspondence and reporting. Administration maintains correspondence files, prepares and submits maintenance reports, and controls maintenance administrtive procedures within the maintenance complex. Classified documents and reports pertaining to equipment, such as nuclear weapons and ECM pods, are maintained and prepared by the activity to which the equipment is assigned.

The Administration activity is responsible for administrative support of the Chief of Maintenance office and the maintenance complex. Administration duties and responsibilities are to:

a. Establish and control a reporting and administration system for all maintenance reports and correspondence.

b. Sort and group maintenance data forms before they are forwarded for keypunch.

c. In coordination with data automation, establish cutoff times for the delivery of documents or punch cards for machine processing.

d. Maintain all correspondence and report files for the Chief of Maintenance, except for the special reference files maintained by each maintenance function.

e. Insure the proper distribution of all correspondence, reports, and publications.

f. Maintain an effective correspondence and reports suspense system.

g. Insure the publication and distribution of maintenance orders, schedules, directives, procedures, reports, and summaries.

h. Accomplish the timely pickup and delivery of maintenance forms and associated reports between the maintenance activities and data automation.

Production Analysis. Production Analysis is the primary management information source for the Chief of Maintenance. It serves as a data surveillance and statistical unit. The overall objective is to provide information to be used to improve the maintenance operation. This is done through the examination of various maintenance management output products and reports and the identification of trends that are developing. This section provides guidance in the application of production analysis techniques. It assists maintenance managers by providing guidance as to what information is available from this activity. It is not intended that all the possible variations in analysis techniques and procedures be included here. The active and questioning analyst finds sufficient guidance and suggestions which can be expanded to accommodate local conditions and requirements. All maintenance managers should become familiar with the interpretation of analysis results. Man-hour and maintenance data equipment status, and other reports received by maintenance in the form of machine listings, contain an abundance of data. As a minimum, Production Analysis duties are to:

a. Collect and maintain data pertinent to the maintenance operation, as well as to review the data for significant trends, and isolate and identify areas which need further study or investigation. When further investigation beyond the technical ability of production analysis is warranted, the problem should be referred to the appropriate staff activities or production supervisors.

b. Prepare studies, summaries, briefings, and presentations as required by the Chief of Maintenance.

c. Identify and analyze trends in equipment performance and maintenance man-hour consumption.

d. Assist maintenance staff functions by identifying and furnishing significant elements of data for use or action by these functions.

e. Assist maintenance activities in the proper application and interpretation of man-hour and maintenance data reports.

f. Coordinate with data automation on maintenance data collection input and output products to insure accuracy and timeliness.

g. Design local workcenter codes within the framework provided by AFM 300-4, *Data Elements and Codes,* ADE MA-353-XI, and TO 00-20-2, *The Maintenance Data Collection System.*

h. Provide Quality Control with necessary statistical and trend information for the Maintenance Standardization and Evaluation Program (MSEP).

Training Management. The purpose of Training Management is to insure that a continuous, well-organized training program is established and managed throughout the maintenance complex.

The maintenance training program consists of these three elements:

a. Qualification training.

b. Management training.

c. Upgrade training (UGT).

The primary role of Training Management in this program is to coordinate training requirements and schedules with the various maintenance activities. This approach permits the most effective and economical use of training resources.

Training Management provides the Chief of Maintenance and unit training supervisors with the status of training and identifies training deficiencies. In this context, training is defined as any instruction provided to increase maintenance technical qualifications and supervisory or management capability. It includes informal training conducted by supervisors and technicians from within the maintenance complex and formal training conducted by activities such as Field Training Detachments (FTDs) and Mobile Training Teams (MTTs), factory schools, and Air Training Command technical schools.

The basic responsibility for training within any organization lies directly with the squadron commander. However, the Chief of Maintenance is responsible for maintaining a balance of skills within the maintenance complex and insuring that maintenance personnel receive all necessary training. As a minimum, Training Management must:

a. Monitor the maintenance training program, as specified in AFM 66-1, *Maintenance Management,* and as further defined by the Chief of Maintenance.

b. Monitor the currency of the required proficiency evaluation, testing, qualification, and certification programs within the maintenance complex.

Programs and Mobility. Programs and Mobility provides the Chief of Maintenance with managerial support in developing and maintaining the currency of programs and plans. Also, this activity performs the function of finance, manning, and facilities management. Plans and Mobility reviews each mission

plan and assures the Chief of Maintenance that the plan is sound and all the contingencies are provided for.

An important function is the development of mobility plans for personnel and equipment. In today's Air Force, entire organizations must be in a constant state of readiness for movement. Plans and Mobility is responsible for developing internal procedures to insure that each maintenance activity is informed of mobility exercise requirements.

Exercises (052):

1. Match the letter corresponding to the section of the Management Support Branch in column B with the duties or responsibilities of that agency listed in column A.

Column A	*Column B*
_____ 1. Monitors currency of maintenance personnel certification.	a. Production Analysis.
_____ 2. Controls a reporting system for maintenance correspondence.	b. Administration.
_____ 3. Prepares studies.	c. Training Management.
_____ 4. Schedules UGT.	d. Programs and Mobility.
_____ 5. Collects and maintains maintenance data.	
_____ 6. Sorts maintenance data collection (MDC) forms.	
_____ 7. Insures publication of maintenance orders.	
_____ 8. Monitors proficiency evaluation.	
_____ 9. Statistically isolates problem areas.	
_____ 10. Picks up MDC forms from maintenance activities.	

2. In the following situation a duty or job is described. From the information given, determine the management support section that is responsible for performing each.

_____ a. This duty requires planning for fiscal control of the Chief of Maintenance budget.

_____ b. If you are going to institute a new workcenter, the responsibility for determining the code for their workcenter lies with this section.

_____ c. Handles the correspondence for the maintenance organization.

_____ d. Taking large amounts of data and analyzing and interpreting it are functions of this section.

_____ e. The keypunching activity may be located at data automation, but the sorting of cards and forms is done by this section.

053. Identify the maintenance squadrons within the maintenance complex in terms of duties, responsibilities, and structure.

The next level of maintenance we'll discuss is the units of the maintenance complex that actually perform the maintenance—the maintenance squadrons. As an airframe repairman, you'll work very closely with each of the maintenance squadrons. Therefore, a knowledge of what each maintenance squadron is responsible for will help you get an overall view of the maintenance complex and a better understanding of why things are done a certain way.

Briefly look again at figure 4-1. Take note of the bottom line. Shown are the maintenance squadrons found in a typical maintenance organizational structure. For our purposes, we'll discuss the four you will have the most contact with: the Organizational Maintenance Squadron (OMS), Avionics Maintenance Squadron (AMS), Munitions Maintenance Squadrons (MMS), and lastly, your own squadron, the Field Maintenance Squadron (FMS).

Organizational Maintenance Squadron (OMS). OMS has physical charge of all assigned aircraft. Each aircraft is, in turn, assigned to an individual usually called a crew chief. He is in charge of the aircraft, aircraft forms, as well as any maintenance personnel assigned to work on his aircraft. Actually, we could say that the whole maintenance complex is organized to support the OMS. The squadron may be divided into the following branches:

Alert Force, Base Flight and Transient, and Flight Line Inspection and Support Equipment.

Avionics Maintenance Squadron (AMS). AMS activity performs maintenance on avionics systems. Avionics systems include such equipment as radio, radar, and electronic countermeasures systems. Some of the branches within an AMS are: precision measurement equipment laboratory (PMEL), communication-navigation, and mission system. The mission system branch may consist of the following shops: bomb navigation integrated system—fire control, automatic flight control—instrument, and photographic sensors.

Munitions Maintenance Squadron (MMS). MMS provides reliable and safe munitions for both conventional and nuclear weapons. If guns are required on assigned aircraft, MMS will provide a gun service section to maintain and inspect gun system components.

The MMS may be divided into a number of branches, depending upon the size of the organization. The maximum size unit consists of: explosive ordnance disposal (EOD), equipment maintenance, nontactical instrumentation, short range attack missile (SRAM), munition services, munitions maintenance, storage, and preload.

Field Maintenance Squadron (FMS). FMS provides maintenance and specialist assistance to other maintenance squadrons. Some of the services they provide are: inspection and equipment support requirements, aircraft engine changes, corrosion control, and replacement of time change items. FMS is usually the largest squadron in the maintenance organization. It expends the most man-hours. Therefore, the way personnel and equipment are used by the FMS will greatly affect the maintenance capability. FMS consists of four branches: fabrication, propulsion, aerospace systems, and aerospace ground equipment. Figure 4-2 illustrates the organization structure for a FMS and shows the individual shops within each branch. Being an airframe repair specialist, your shop, the Structural Repair Shop, is located in the Fabrication Branch. You will work very closely with specialists within each of the branches.

Exercises (053):

1. In the space provided in front of each of the following items, place the initials of the maintenance squadron to which the item refers.

_____ a. Maintains electronic camera equipment.
_____ b. Changes aircraft engines as needed.
_____ c. Responsible for the upkeep of assigned aircraft.
_____ d. Has corrosion control capabilities.
_____ e. Maintains and inspects gun system components.
_____ f. Usually the largest maintenance squadron.
_____ g. The whole maintenance complex supports the squadron.
_____ h. Operates a PMEL section.
_____ i. Has an Alert Force Branch if required.
_____ j. Greatly affects the maintenance capability.

2. Use figure 4-2 and in the space provided in front of each of the following shops in column A, place the letter representing the branch of a FMS to which the shop belongs shown in column B.

Column A	*Column B*
_____ 1. Environmental.	a. Fabrication.
_____ 2. Propeller.	b. Propulsion.
_____ 3. Survival Equipment.	c. Aerospace systems.
_____ 4. Test cell.	d. Aerospace ground equipment.
_____ 5. Pneudraulics.	
_____ 6. Accessory repair.	
_____ 7. Powered AGE.	
_____ 8. Nonpowered AGE.	
_____ 9. Metals processing.	
_____ 10. Electrical.	

4-2. Aircraft Inspection and Maintenance Systems

To keep aircraft as safe as humanly possible, the Air Force has developed a system of maintenance and inspection that is considered to be the finest in the world. This system is continually undergoing improvement. The aircraft is not only examined for sources of possible malfunctions; in addition, discrepancies which are detected are immediately repaired. Records are kept and analyzed to provide data for further improvement of the system.

In keeping with our discussion of maintenance, let's turn our attention to the systems used to accomplish maintenance, particularly the inspection system.

054. State the three levels of maintenance, and characterize the maintenance accomplished at each level.

Levels of Maintenance. The three levels of maintenance from lowest to highest are: organizational, intermediate, and depot. The overall maintenance and inspection policies are formulated by Air Force Logistics Command (AFLC). To support all Air Force organizations AFLC has established air logistics centers that are charged with depot class maintenance.

The major commands engaged in actual flight-line operations are divided into numbered Air Forces and divisions. An air division is further divided into wings, which are normally the smallest self-sufficient units.

Organizational maintenance. Organizational maintenance is limited in scope. This level of maintenance includes routine inspections, replacement of some components, minor structural repairs, and servicing with fuel, oil, etc. Organizational maintenance may also perform technical order modifications that can be performed with the facilities available at the organizational level.

It is of the utmost importance that technicians at organizational level discover indications of equipment failure soon enough to prevent major component failure. Failure to discover these indications results in an increase in the workload of other levels of maintenance. This may result in disruption of maintenance schedules, not to mention in-flight failure with the possibility of loss of life and equipment.

Intermediate maintenance. Closely supporting the organizational level of maintenance is the intermediate level of maintenance. Personnel in the field maintenance activity, usually a field maintenance squadron (FMS), perform maintenance at the intermediate level. The FMS usually has the highest concentration of skilled specialists and costly equipment in the maintenance organization. You will find such shops as engines, fuel systems, electrical, pneudraulics, and egress—just to name a few—at this level. The actual number will de-

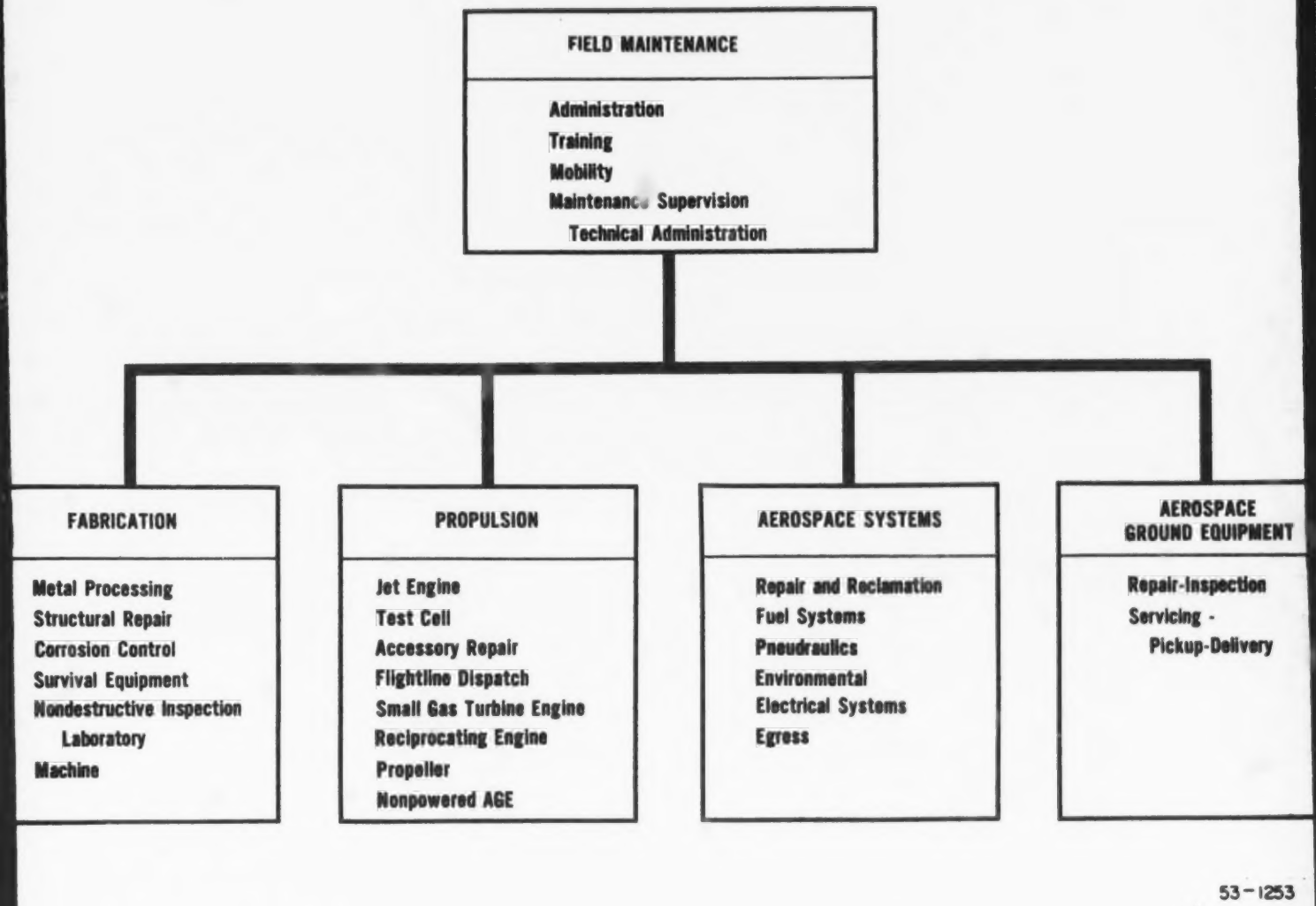

Figure 4-2. Organizational Chart for the Field Maintenance Squadron.

pend on the mission and the size of the organization—in other words, *need*. If the Chief of Maintenance decides that there is a need for a function (shop), then the organization will make a provision for it.

The support provided by this echelon (level of maintenance) consists primarily of furnishing specialist assistance to organizational line maintenance, performing bench checks of equipment, and maintenance repair that is beyond the capabilities of the organizational unit. When the capabilities of the maintenance activity at the intermediate level are exceeded, the problem becomes a matter for depot level maintenance.

Depot maintenance. The highest level of maintenance requires extensive equipment to perform major repair and overhaul. The chief function of a depot is the performance of major modifications on aircraft and all aircraft components. All systems are inspected and repaired as necessary (IRAN). Depots also supply spare parts, aerospace ground equipment, and technical order compliance kits to organizational and field maintenance units through normal supply channels.

Exercises (054):

1. What level of maintenance performs minor maintenance on its assigned aircraft?

2. Field maintenance shops perform what type of maintenance?

3. State the levels of maintenance from the lowest to highest level.

4. At what level of maintenance are all systems inspected and repaired as necessary?

5. Which level of maintenance provides most of the specialists in the maintenance organization?

055. Differentiate between the types of inspections accomplished under the periodic concept of inspections.

Periodic Inspection Concept. There are three authorized scheduled inspection concepts used by the Air Force. These are periodic, phased, and isochronal. The first one we'll discuss is the periodic concept which is subdivided into five elements:

a. Preflight (PR).
b. Thruflight (TH).
c. Basic postflight (BPO).
d. Hourly postflight (HPO).
e. Periodic (PE).

Preflight. The preflight inspection, as the name implies, is basically a flight preparedness check. As such, this inspection is performed before resuming flying activity after the aircraft has been inactive for an extended period of time. On this basis, the preflight inspection is required before the first flight of the day. The inspection is a thorough visual inspection and operational check of certain systems and components to assure that no defects exist that could cause accidents or mission aborts.

Aircraft on alert status will have a complete preflight inspection accomplished before going on alert status and again before flight after completion of the alert period. Continuous surveillance by the aircrew and accomplishment of alert and scramble checklist should insure that the aircraft is airworthy.

Aircraft used for airline type operations will normally require a preflight during routine intermediate stops. However, when the stopover involves a period of many hours extending into the normal work period of the next calendar day, a new preflight may be required.

Thruflight inspection. The thruflight inspection was designed for use on cargo aircraft utilized for regular airline type operations. It is, however, applicable to any aircraft where an immediate turn around or a continuation flight is scheduled. This inspection will be performed before take off at intermediate stops. The aircraft is visually checked to see if there are any defects which could impair safety of flight. The scope of the thruflight will be governed by the inspection concept under which that particular weapon system is being operated.

Basic postflight. The basic postflight inspection will be accomplished after the last flight of the flying period. This inspection consists of checking the aircraft to determine if it is suitable for another flight by performing a visual examination of certain systems and components to assure that no defects exist which would be detrimental to further flight.

Maintenance is not obligated to perform the basic postflight inspection until the aircraft is released by operations. If an aircraft lands to change pilots or other crew members, or if an aircraft makes a brief stop with the crew staying in the immediate area of the aircraft, the basic post-flight inspection need not be performed, since the aircraft has not been released by operations. The basic postflight inspection is a more thorough check than the preflight or the thruflight inspections.

Hourly postflight. The hourly postflight inspection is accomplished after a specified number of flying hours have accumulated. It consists of checking certain component areas and systems of the aircraft to make sure that no conditions exist which could result

in failure of the component before the next scheduled inspection. This inspection augments the basic postflight. In fact, the basic postflight is often accomplished at the same time. For example, if an aircraft has flown and has also accumulated the specified number of hours for the hourly postflight then the hourly postflight and basic postflight inspections will be accomplished at the same time.

Periodic. The periodic inspection is a thorough and searching inspection of the entire aircraft, more extensive than the hourly postflight or basic postflight inspections. In addition to the recurring inspection items, some of which are required at the hourly postflight inspections, the periodic inspection includes certain components, areas, and systems of the aircraft that require less frequent inspection (because of their function) than the hourly postflight or the basic postflight.

The periodic inspection is considered due when the specified number of flying hours or calendar period has expired. As in the case of the hourly postflight, the aircraft should not be scheduled for flight if the mission will over extend the inspection by too great a margin.

Exercises (055):

1. Describe the circumstances that calls for a preflight inspection.

2. Why are basic postflight inspections performed?

3. When are hourly postflight inspections accomplished?

4. What determines when a periodic inspection will be accomplished?

5. Describe the circumstance that calls for a thruflight inspection of an aircraft.

056. Define and state the purpose and frequency of phased inspections.

Phased Inspection. The phased inspection concept is actually a combination of the basic postflight and/or hourly postflight and periodic inspection requirements into small packages. These packages have approximately the same work content and clock hours. Lumping these three inspections into one would make an inspection that requires an extremely long time to complete. Therefore, this inspection is broken into parts or phases. The amount of flying time accrued between phases depends upon the aircraft and its use. For example, the B-52G phased inspection consists of 24 phases. Phase 1 is at 25 hours, phase 2 at 50 hours, phase 3 at 75 hours, etc., with phase 24 at 600 hours. At 625 hours the sequence would start again with phase 1, and the cycle would repeat itself indefinitely.

One of the main objectives of the phased concept is to reduce the time the aircraft is out of commission for any given inspection. The phases are arranged in such a manner that each requires approximately the same number of man-hours. This arrangement permits all inspection requirements to be met with a short out-of-commission time for any one phase.

Figure 4-3 shows a sample card from a set of work cards for a phased inspection. The headings at the top of the card provide some important information. By reading the information in the heading blocks we know the card number, the work area, the publication number and date, the type mechanic required to perform the work, and whether or not the electrical power must be on or off. Also, we can tell at which phase or phases these particular items must be inspected.

Exercises (056):

1. What is a phased inspection?

2. What is the purpose of phased inspections?

3. What determines when phased inspections will be accomplished?

057. Identify the inspection requirements under the isochronal concept of inspection.

Isochronal Inspection. The isochronal concept of inspection is the last of the three authorized inspection concepts. Isochronal means "at equal intervals." There are three inspection requirements under the isochronal concept; the home station check, the minor check, and major check.

Home station check. The home station check (HSC) inspection consists of requirements that are a combination of former basic postflight and hourly postflight items. These items are arranged and designed for accomplishment at the home station when the aircraft returns from a long range mission or upon expiration

CARD NO.	WORK AREA(S)	TYPE MECH RQR	MECH NO.	CARD TIME	PUBLICATION NUMBER AND DATE	CHANGE NO.
C-035	2	ACFT MECH		00:027	1B-52B-6WC-2 1 NOV 75	

MAN MIN	WORK AREA	WORK UNIT CODE SYS	WORK UNIT CODE SUB-SYS & COMP	INSPECTION REQUIREMENTS	ELECTRICAL POWER	SERVICE	FIGURE	CARD NO.
				2ND PH	OFF			C-035

ENGINES 1 AND 2

005	2	23	KQC	1.	STARTER CONTROL VALVE FOR CHAFING, LOOSE CLAMPS, LOOSE OR BROKEN ELECTRICAL CONNECTOR, AND LOOSE OR BROKEN LOCKWIRE.
005	2	23	KQJ	2.	STARTER (TYPE STU-11A/34) SEPARATOR PLATE AND EXHAUST HOUSING INNER FLAME DEFLECTOR RING FOR CRACKS. HOUSING (P/N 690015A) HAVING CRACKS LOCATED BETWEEN INNER FLAME DEFLECTOR RING AND SEPARATOR PLATE ARE ACCEPTABLE IF THE CRACKS DO EXCEED 1/16 INCH IN WIDTH. HOUSINGS HAVING CRACKS LOCATED BETWEEN SEPARATOR PLATE AND FAN EXHAUST PORT ARE ACCEPTABLE.
005	2	23	KQJ	3.	ENGINE STARTER (TYPE STU-11A/34) BREECH CHAMBER DOME, LUGS, AND SEATS FOR CARBON DEPOSITS. TRANSFER TUBES FOR CRACKS AND BURNED THROUGH HOLES. IN OUTER SHELL, CLAMPS FOR LOOSENESS, ELECTRICAL CONTACT PINS FOR DIRT, OIL OR CARBON DEPOSITS. (NOTE: CLEAN WITH CLOTH OR SCOURING PAD. DO NOT USE LIQUID.) CLEAN ELECTRICAL CONTACT PIN BY USE OF CLEAN LUB FSN 6850-664-5640 OR EQUIVALENT. (USE ON ELECTRICAL CONTACT PIN ONLY.)
010	2	23	KQJ	* 4.	BREECH CAPS CLEANED AND STOWED.

CARD NO.	WORK AREA(S)	TYPE MECH RQR	MECH NO.	CARD TIME	PUBLICATION NUMBER AND DATE	CHANGE NO.
C-035	2	ACFT MECH		00:027	1B-52B-6WC-2 1 NOV 75	

53-1255

Figure 4-3. Sample work card.

of a specified short term calendar interval. This inspection will become due and will be performed at the calendar interval specified in the -6 inspection work cards. This inspection will also be accomplished in conjunction with minor and major inspections.

Minor inspection. The minor inspection will become due upon the accrual of the number of calendar days specified in the applicable -6 inspection manual and -6 work cards. This inspection consists of checking certain components, areas, or systems of the aircraft to determine that no conditions exist which could result in failure before the next scheduled inspection.

Aircraft should not be scheduled for a mission of a duration that will exceed the specified limitation to the extent that safety of flight would be jeopardized.

Major inspection. This inspection is a thorough and searching inspection of the entire aircraft or weapon system. Individual requirements may be more extensive in scope than previous inspection items. The major inspection will become due when the number of calendar days specified in the applicable -6 inspection manual and work cards has accumulated. The inspection will include certain components, areas, and systems of the aircraft or weapon system which, due to their function, require less frequent inspection than those required by other inspections.

Because of the length of time normally required to complete a major or minor inspection, it is inadvisable to include preflight inspection requirements as part of the major or minor inspection. Therefore, a separate preflight inspection will be required before the aircraft is released for flight.

When an aircraft does not fly or is out of commission for more than 30 consecutive days, a basic postflight or home station check inspection will be required before the aircraft can be released for flight. This will be considered as a minimum 30-day calendar inspection.

When an aircraft is idle for more than 90 consecutive days, an hourly postflight inspection or home station check, plus performance of an operational check of all functional aircraft systems (excluding landing gear retraction), and accomplishment of all periodic or minor lubrication requirements will be required before the aircraft is returned to operational status. As is the case for the 30-day calendar inspection, this will be considered a minimum 90-day inspection. In both the 30- and 90-day inspections, the local commander and the maintenance officer will determine whether additional inspection or maintenance is required.

Exercises (057):

1. What inspection is performed at specific intervals and concurrently with minor and major inspections?
2. Home station checks are accomplished in conjunction with what types of inspections?
3. When an aircraft is out-of-commission for more than 30 consecutive days, what type inspection is required?
4. When an aircraft is idle for more than 90 consecutive days, what type of inspection should be performed?

058. Distinguish between "inplace" and "dock" methods of inspections.

Methods of Inspection. The two methods of inspection currently used are the inplace and dock methods. The inspection crews are supported by specialists dispatched from the various shops. A maintenance unit may use one or both methods of inspection. The local or major command will decide which method best meets their mission requirements.

Inplace method. The inplace method is used when maintenance and operational requirements dictate that inspections and maintenance must be performed at the equipment location. If the inplace system is used on aircraft it may take the form of one or more ground crews assigned or dispatched to a particular aircraft. The highest ranking member of the crew is usually designated as the crew chief. He supervises all operations performed by the crew.

Dock method. The dock method is used when maintenance and operational requirements dictate that the equipment be moved to a fixed station or site for accomplishment of inspection and maintenance. The required maintenance crews may be permanently assigned to such stations or sites.

Dock structures may be designated to hold an aircraft, or at least the major portion of the aircraft, so that working personnel are protected from the elements. When small aircraft are involved, a dock may be a designated area inside a large maintenance hangar. The dock facilities include items constantly being required, such as compressed air, an aircraft power supply, lights, heat, as well as necessary bench stock (nuts, bolts, screws, etc.). These items are needed to save man-hours that would be required to supply them on a recurring basis.

Latrine facilities, built-in workstands, and an office equipped with a telephone and intercom increase efficiency. Efficiency is further increased by preplanning. Jobs are plotted on a sequence chart so that each specialist and mechanic is scheduled to perform main-

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Figure 4-4. Maintenance symbols.

tenance tasks with minimum interference with each other. Supplies, parts, and replacements that are known to be needed are procured in advanced and prepositioned in the dock.

Exercises (058):

1. What is meant by the inplace method of conducting an inspection?

2. Describe the dock method of performing inspections.

4-3. Maintenance Forms

Information concerning maintenance actions must be recorded on "something." Three maintenance forms, which you use most often, are the AFTO Form 781 series, AFTO Form 349, and AFTO Form 350. These have been developed to provide a systematic way of recording and collecting maintenance actions.

The AFTO Form 781 series is maintained at the aircraft to present a clear picture of the status and condition of the aircraft. The AFTO Forms 349 and 350 are used to record maintenance accomplished on the aircraft and control parts removed from the aircraft for repairs in the maintenance shop. The AFTO Forms 349 and 350 provide the necessary data for the Maintenance Data Collection System.

059. State the purpose of maintenance symbols, and differentiate between those used to record unsatisfactory conditions on the AFTO Form 781 series.

Maintenance Symbols. Symbols, or special characters, are used on maintenance forms to make important information instantly apparent and to save space on maintenance forms. We will study five of the more commonly used maintenance symbols. These symbols are explained in greater detail in T0 00–20–1 and T0 00–20–5. In figure 4-4 you can see the five symbols we will discuss.

Red X. The red X symbol is the most serious and indicates that an aircraft or a piece of equipment is unsafe and may not be used. An aircraft is grounded or a piece of equipment is restricted from use until the unsafe condition has been cleared. A red X symbol is enterd on the maintenance forms for the following conditions:

- A major discrepancy.
- A safety of flight condition (work being done on a critical part of the aircraft).
- A piece of equipment is unsafe or unfit for use.

After a red X condition is corrected, it must be inspected by a qualified inspector who will then clear the symbol by placing his last name initial over it and writing his minimum signature in the "Inspected by" block. (Minimum signature consists of your first name initial and your last name.)

Circled red X. The circled red X symbol is used *only* for Urgent Action time compliance technical orders (TCTOs). It is the second most serious symbol and is used to ground the aircraft (aircraft is not allowed to fly) when work has begun on, or the time limit has expired on, an Urgent Action time compliance technical order. A circled red X condition must also be signed off by a qualified inspector.

Red dash. The red dash symbol is the third symbol. It indicates that the condition of the equipment is unknown (a *scheduled* inspection is due or overdue on an aircraft or piece of equipment). A red dash also indicates that an accessory replacement, operational checkout, special inspection, or functional check flight, although due, has not been completed.

Red diagonal. The red diagonal symbol is the least serious of the red symbols. It indicates that an unsatisfactory condition exists, but is not serious or dangerous enough to prevent using the aircraft or equipment. A red diagonal symbol is entered on the maintenance forms to indicate a minor discrepancy. The red dash and red diagonal symbols can be signed off by the mechanic who corrects the defect.;

Black last name initial. The last symbol, shown in figure 4-4, is the "black last name initial." This symbol, when entered in the aircraft or equipment, indicates that there are no discrepancies. When it is entered over a red symbol it indicates that the person whose name appears in the Corrected By block has accomplished the required maintenance or inspected the equipment or system and finds its condition satisfactory, which clears the symbol.

Other red symbols. The red letters N, B, and C inside a red circle indicate that the aircraft may be contaminated with a nuclear, biological, or chemical agent:

N – (Nuclear).
B – (Biological).
C – (Chemical).

Exercises (059):

1. What is the purpose of maintenance symbols?

2. In the space provided in front of each statement, place the required maintenance symbol.

_____ a. Condition exists that is not serious or dangerous enough to prevent use of the aircraft.

_____ b. Indicates an Urgent Action time compliance technical order (TCTO) is required.

_____ c. The most serious maintenance symbol.

_____ d. Condition of aircraft is unknown.

_____ e. Used when no discrepancies exist on the aircraft.

_____ f. Indicates the aircraft is chemically contaminated.

060. Organize the entries on an AFTO Form 781A from discovery to completion of a maintenance action.

AFTO 781 Series Forms. A set of AFTO 781 series forms, (aircraft flight report and maintenance records) is maintained for each aircraft in the Air Force inventory. These forms are maintained in a loose-leaf binder that is kept in the aircraft.

The AFTO 781 series forms have gone through many changes and revisions. This is understandable, since the purpose is to design a set of forms that will present a clear picture of the status and condition of the aircraft.

Entries are made by several different persons in varying capacities. The flight crew, crew chief, mechanics, and specialists are authorized to make entries on one or more of the AFTO 781 series forms.

The crew chief or his alternate will assure that enough copies of AFTO Forms 781 are aboard the aircraft. Also, he will remove forms from the binder, transcribe open write-ups to a new AFTO Form 781A, and forward the removed forms to the maintenance officer. After a review by the maintenance officer, the AFTO Forms 781A are forwarded to the documentation activity for filing.

The AFTO Form 781A is basically a simple form and almost self-explanatory. The information that follows has been condensed from T0 00-20-5. It is meant to supply sufficient information to complete this text and is not complete in all details. Always remember to check the latest 00-20-5 and related technical orders when using this form in an actual maintenance situation.

The AFTO Form 781A shown in figure 4-5 illustrates examples of typical entries made on this form. Most of the time you'll be completing the right-hand column indicating what maintenance you've performed. Occasionally, during the course of your maintenance you'll discover discrepancies. Therefore, procedures for completing the left-hand column are included in our discussion.

Left-Hand Column Entries. The required entries in the left-hand column necessary to accurately depict a discrepancy are described in the following paragraphs.

SYM block. Enter the proper symbol for each discrepancy (red X, red dash, etc). When a discrepancy is corrected, an initial will be placed over the symbol. Red dash and red diagonal symbols will be initialed over by the individual who performs the corrective action. If the defect carried a red X or circled red X symbol, *the corrective action must be inspected and signed off by an inspector or supervisor designated to clear red X symbols.* Specific instructions for clearing red X symbols are contained in T0 00-20-1.

NOTE: Never erase a symbol entered in error. If a symbol is entered in error, make the following applicable statement in the corrective action: "Symbol entered in error, discrepancy and correct symbol entered below," or "Symbol entered in error, no discrepancy exists." Then sign the Corrected By block and initial over the erroneous symbol. If the erroneous symbol is a red X, the erroneous entry must be verified by an individual authorized to clear red X symbols.

Date Discd, WDC, JCN, Tag NO, Discrepancy, and DN. The person entering the defect will print the Date Discovered, when discovered code (WDC), and a description of the defect. If a pilot makes the entry he will enter the number of his flight on the first vacant line in the Discrepancy block. *Example:* Flt No 1. The crew chief will enter the job control number (JCN) (when assigned) and the supply document number (SDN) if parts are ordered.

Only one discrepancy will be entered for each discrepancy block. However, as many discrepancy blocks as necessary may be used to complete a single discrepancy.

The pilot or aircrew member will enter his signature and grade in the Discovered By block of his last entry. Maintenance personnel will enter their signature and grade in the Discovered By block for each discrepancy they enter.

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DATE FROM	TO	CREW CHIEF	ORGN	LOCATION	MDS	SERIAL NO.
10/07/3	12/07/3	M.GRIFFIN SSgt	60th MAW	TRAVIS AFB,CA	C-141A	61-0164

SYM	DATE DISCD	WDC	JCN	TAG NO	CF TO 781A P	DATED	TRANSFERRED TO 781K	DATE	TRANSFERRED BY
X	10/07/3	D	1610021			/ /		/ /	

DISCREPANCY: FLT. No.1, No.1 THROTTLE OUT OF ALIGNMENT.

CORRECTIVE ACTION: THROTTLE LINKAGE ADJUSTED. OPERATIONAL CHECKED O.K.

DATE CORRECTED: 10/07/3

DN	DISCOVERED BY	CORRECTED BY	INSPECTED BY
		J. Rozar, Sgt.	

SYM	DATE DISCD	WDC	JCN	TAG NO	CF TO 781A P	DATED	TRANSFERRED TO 781K	DATE	TRANSFERRED BY
8	10/07/3	D	1610022	857892		/ /		/ /	

DISCREPANCY: FLT. No.1 PILOTS MIKE BUTTON STICKS.

CORRECTIVE ACTION: REMOVED AND REPLACED PILOTS MIKE BUTTON. OPERATIONAL CHECK O.K.

DATE CORRECTED: 10/07/3

DN	DISCOVERED BY	CORRECTED BY	INSPECTED BY
X103FL3161013S		P. Schurr, SSgt.	

SYM	DATE DISCD	WDC	JCN	TAG NO	CF TO 781A P	DATED	TRANSFERRED TO 781K	DATE	TRANSFERRED BY
X	10/07/3	D	1610023	857697		/ /		/ /	

DISCREPANCY: FLT. No.1 LOST FUEL FLOW No.1 ENGINE T.O. PLUS 1 HR. ALL OTHER INSTRUMENTS NORMAL.

CORRECTIVE ACTION: REMOVED AND REPLACED No.1 ENGINE FUEL FLOW TRANSMITTER SYSTEM CHECKED O.K. IAW TO 1C-141A-2-4

DATE CORRECTED: 10/07/3

DN	DISCOVERED BY	CORRECTED BY	INSPECTED BY
X103FL3161018I	K. Denniston, Capt.	H. Hagan, MSgt.	A. Nickerson, SMSgt

SYM	DATE DISCD	WDC	JCN	TAG NO	CF TO 781A P	DATED	TRANSFERRED TO 781K	DATE	TRANSFERRED BY
	/ /					/ /		/ /	

DISCREPANCY:

CORRECTIVE ACTION:

DATE CORRECTED: / /

DN	DISCOVERED BY	CORRECTED BY	INSPECTED BY

AFTO FORM MAY 73 781A **MAINTENANCE DISCREPANCY AND WORK DOCUMENT** PREVIOUS EDITION IS OBSOLETE

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Figure 4-5. AFTO Form 781A.

When a part is returned to supply or routed through the reparable processing center (RPC), the individual removing the item will enter the tag number of the AFTO Form 350, Reparable Item Processing Tag, in the appropriate block.

Right-Hand Column Entries. The required entries for completion of the right-hand column are described in the following paragraphs.

Corrective Action. When a defect is corrected, a brief description of the corrective action will be documented in the Corrective Action block and the date will be entered in the Date Corrected block.

Corrected By. The individual making the correction enters his name in the Corrected By block. He uses the minimum signature—that is, his first name initial, full last name and rank. He also places his last name initial over the maintenance symbol if the discrepancy was *not* a red X or circled red X condition.

Inspected by. The Inspected By block is used by the inspector (7 level) who has checked the maintenance accomplished in correcting a red X or circled red X condition. He also uses the minimum signature method and enters the first initial of his last name in the maintenance SYM block.

Exercise (060):

1. Using the following information, make entries on the AFTO Form 781A, shown in figure 4-6.

   A1C H. Jones found a red X condition consisting of loose rivets in the intake of No. 2 engine on 1 July 1975. The when discovered code (WDC) is F and the job control number is 1830066. The discrepancy was corrected by Sgt A. Smith by replacing the loose rivets. MSgt H. Madison was the inspector. The discrepancy was corrected on the day the condition was discovered. The aircraft is a C-141A type aircraft.

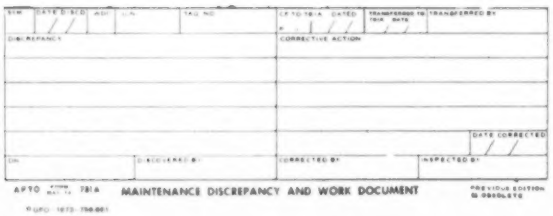

Figure 4-6. Objective 060, exercise 1.

061. State the purpose and function of the maintenance Data Collection System, and identify the categories of documentation.

Maintenance Data Collection System. The Maintenance Data Collection System is a management tool. Its purpose is to tell maintenance managers what production jobs are performed by the men or women assigned to each organization or workcenter, how many man-hours were expended on each job (unit of work), when the malfunction was discovered, who did the work, why the repair was required (how malfunction), and what kind of repair was required (action taken). This information makes it possible for maintenance managers to determine problem areas and manpower and spare parts requirements. The main point to keep in mind about the Maintenance Data Collection System is that it does not solve problems, but merely identifies them for appropriate management actions. Standard forms are used by all organizations throughout the Air Force, and the proper completion of these forms provides valid input into the system.

The increasing use of this information in all elements of the Air Force makes it mandatory that everyone concerned with the recording of data insure accurate recording. Incomplete or inaccurate maintenance data will result in erroneous manning, equipment, budgeting, configuration records, or unrealistic work requirements. How would you like your unit to be levied with a work requirement that would stretch manpower requirements to the limit—maybe necessitate some people working overtime 2 or 3 days a week —especially if *you* were the one doing the overtime? Therefore, it is very important that all entries on the maintenance forms be accurate and clearly written so that the keypunch operator can read and correctly keypunch the information on the data processing cards.

All Maintenance Data Collection data is grouped into one of three categories. Data documented to describe maintenance performed on end items of equipment is categorized as "on-equipment." This is the work accomplished at the aircraft. Data documented to describe maintenance performed on parts removed from the end item of equipment (aircraft), is categorized as "off-equipment." This is when parts are sent to the shop for repair. The third category, "productive indirect," identifies those productive indirect hours that are expended for leaves, details, compensatory time-off, training, and alert duty. By documenting within the appropriate categories, both on base and off base, users will have available this data which fully describes where, when, what, and how maintenance production resources are being used.

Exercises (061):

1. State the three determinations that maintenance managers can make using the Maintenance Data Collection System.

2. What is the "key" factor that determines if the Maintenance Data Collection System works?

3. Scheduled and unscheduled flight-line work accomplished on the aircraft requires what category of documentation on the maintenance collection forms?

4. Parts received from supply for repair would require which category of maintenance documentation?

5. Which category of documentation is *not* directly involved with accomplishing maintenance?

062. Identify AFTO Forms 349 and 350 in terms of origination, content, use, and/or format.

AFTO Form 349. The AFTO Form 349, Maintenance Data collection Record, is the principal source document for the Maintenance Data Collection System. It is a multipurpose form used to record maintenance actions, and when a copy of the form is given to a specialist, it also serves as a dispatch notice. Recording the maintenance actions taken in performing the work provides a production credit record and an input into the Maintenance Data Collection System for subsequent analysis and management use.

The efficiency of maintenance management depends upon the information fed into the system. Every worker should make sure that all the required entries on the AFTO Form 349 are made properly and accurately. The computer would be worthless, and maintenance management would break down, without the full cooperation of the personnel in the shops. All of the blocks and columns in AFTO 349 do not have to be annotated for every job you perform. Later, we will discuss the blocks commonly used by most shops.

AFTO Form 350, Reparable Item Processing Tag. This tag is attached to equipment components, serving as an identification and status tag. Any part that is defective, or thought to be defective, and is removed from an end item is called a reparable item or part. All reparable items must be tagged with an AFTO Form 350. The shop repairman needs the information recorded on this form when he checks and repairs the part. The AFTO Form 350 is divided into two parts by perforations. Each part is labeled in its lower right-hand corner as either AFTO Form 350, Part 1, or AFTO Form 350, Part 2. Part 1 is the processing document and is completed by the originating agency. Part 2 is the schedule control document and is completed by the reparable processing center (RPC).

Exercises (062):

1. Who completes AFTO Form 349, and what is recorded on it?

2. Completed AFTO 349s are the principal source documents for what system?

3. Give two uses for an AFTO Form 349.

4. What kind of equipment must be tagged with AFTO Form 350?

5. Name the parts of an AFTO Form 350.

063. Construct a job control number for an AFTO Form 349.

For the time being, our attention is directed toward the entries on the AFTO Form 349. Only entries that you'll use for a flight-line dispatch situation will be covered at this time. Entries are made before accomplishing the job, and after completing the job additional entries are entered. This is how our discussion approaches the use of the AFTO Form 349.

At this time, open foldout 1, Documentation for AFTO Form 349, located at the back of the volume. As we progress in our discussion, you'll be researching information from the figures shown in foldout 1 and recording that information on the AFTO Form 349 illustrated. It is suggested that you check the answers to the exercises after making an entry in figure 1 of foldout 1. If a wrong entry was made, reread that particular section and make the necessary correction before proceeding; the reason being is that certain entries are interrelated, and one entry dictates what

another will be. With this in mind, we'll proceed into our discussion of job control numbers.

Prior to accomplishing a job, certain entries are needed to get you started. The following discussion deals with these entries.

Job Control Number (Block 1). The job control number (JCN) ties together all on-and-off equipment actions taken on the same job, including man-hours expended and parts consumed. The job control number is also the primary method of controlling the jobs to be accomplished. Only authorized maintenance tasks are assigned a job control number, and maintenance is not authorized without a job control number. Every job-related action taken, regardless of workcenter, time, or place, carries the job control number that was originally assigned to the job. This procedure permits the control of all related actions and ties them together in Data Systems to identify the total job for analysis purposes.

The job control number contains seven digits. The first three characters constitute the Julian day. This is the day of the year and is found at the bottom of a military calendar. For example, the Julian day for the 28th of January is 028, the 28th day of the year. The last four digits identify the job and normally consist of a daily or monthly job sequence number, such as 0001 for the first job of the day or month. Using the information given above, the job control number for the first job on the 28th of January would be 028-0001. This number would be entered in block 1 of AFTO Form 349.

Exercise (063):

1. You have been assigned the third job of the month on the 16th of January. Construct and record the job control number in block 1 of figure 1 of foldout 1.

064. Develop a workcenter code for an AFTO Form 349.

Work Center Block. The workcenter block identifies the shop of the individual performing the maintenance. Standard work codes are used by all organizations engaged in maintenance functions. A complete listing of workcenter codes is contained in T0 00-20-2. The workcenter code is a 5-character number. The first digit can either be an alphabetic or numeric character identifying the division, wing, or command located on the base. The second character identifies the squadron or function within the maintenance complex. The number 3 is always used to identify the field maintenance squadron. The third and fourth characters identify a shop or branch within the squadron indicated by the second digit. The fifth and last character indicates a subsection of the shop or branch identified by the third and fourth characters. The number 0 is used as the fifth character when a sub-section isn't identified.

Exercise (064):

1. Record the workcenter code in block 2 of figure 1 on foldout 1, if the identifying code for your command was A and your shop code was 13 with no subsection. Your maintenance squadron is the Field Maintenance Squadron.

065. State the use of the I.D. No./Serial No., block 3, identify the individual characters that make up an I.D. No./Serial No., and complete block 3 using given information.

The I.D. No./Serial No. consists of six characters and is used to identify the equipment on which work is performed. The first character of the I.D. No./Serial No. is the first character of the owning workcenter code. The second character is the first character (prefix) of the equipment classification code, such as A for aircraft, E for ground radar, or M for ground launched missiles. The last four characters are normally the same as the last four positions of the equipment serial number. Below is a breakdown of a typical I.D. number.

Example: AA 3407

Owning workcenter	A
Prefix of equipment classification code	A
Equipment serial number	3407

The I. D. No./Serial No. is a unique code, and its use must be understood in order to know how certain data elements are entered into the Maintenance Data Collection System. Identification of an item or a group of items is required so that an accurate account of the maintenance accomplished on these items can be recorded. Therefore, it is important that the entry made in block 3 be correct. This entry, along with the entry in block 9, Location, assures that the proper piece of equipment is being repaired.

Exercises (065):

1. Why is it important that the correct I.D. No./Serial No. be used?

2. In the space provided in front of each item, identify the components of the I.D. No./Serial No., BA6153, that corresponds to the items.

_____ a. Equipment classification code.
_____ b. Workcenter code.
_____ c. Equipment number identifier.

3. Indicate in block 3, figure 1 of foldout 1, the I.D. No./Serial No. for an aircraft, whose owning work-center code is A and the aircraft's serial number is 69-3407.

066. Indicate the use of equipment classification designators.

Equipment Classification Designator Code (Block 5). Equipment classification codes identify the item of equipment that is being repaired. These codes are used in computer programs to facilitate the processing of specific equipment information. Without this capability, processing maintenance data would be much more complex and limited. The authorized abbreviation for "equipment classification code" is EQ/CL. The code contains three characters. The first character identifies a general type of equipment. The next two characters identify the individual item. The EQ/CL codes for individual jobs must be obtained from TO 00-20-2. An entry is not required in this block if an I.D. No./Serial No. is entered in block 3.

Exercises (066):

1. What are equipment classification codes used for?

2. Is an EQ/CL code required in figure 1, foldout 1? Explain your answer.

067. Interpret the priority indicator used in block 7, and from given information, assign and enter a priority on AFTO Form 349.

Priority Codes. The priority block is used to assign job importance. The lower the number, the higher the priority. For example, priority 1 work must be done now, while priority 3 work will have to wait. When a job is scheduled, its priority is assigned by Job Control. The priority is based upon "mission essentiality." The following are guidelines that Job Control uses in setting the priority of a job. These are the ones you'll most often work under.

Priority 1. This priority is reserved for primary mission aircraft on alert status, war plan national emergency missions, and ICBMs requiring critical repair. Maintenance is not normally preplanned on priority 1. Required maintenance involving safety of flight on priority 1 aircraft or missiles would have to be accomplished immediately, and maintenance not involving safety of flight would be deferred until after the alert posture is ended on that particular weapon system.

Priority 2. This priority is used when a primary mission aircraft is within 6 hours of a scheduled launch and for the first 8 hours after landing. For example, if a particular aircraft is scheduled to fly at 1200 hours for 2 hours, all work done on it from 0600 to 1200 and 1400 to 2200 hours that day would be assigned priority 2.

Priority 3. The priority 3 is used for scheduling specialist and support equipment to primary mission aircraft in scheduled inspections (PEs, HPOs, Phase, Isochronal, etc.) and for unscheduled maintenance on aircraft not within 6 hours of flight. From the above, you can see that most preplanned maintenance is accomplished on priorities 2 and 3. Remember that the priority assigned to a particular maintenance task depends on the aircraft usage and not the task.

Priority 4. This priority would be used for routine repairs of nontactical and administrative type aircraft, unless such an aircraft is scheduled to fly and can qualify for priority 3 assignment.

Exercises (067):

1. Who assigns job priorities?

2. Match the priority required in column 2 with the given statement in column 1 by placing the priority code in the space provided in front of each statement in column 1.

	Column 1	*Column 2*
_____	a. National emergency mission.	1
_____	b. Primary mission air vehicles undergoing scheduled inspections.	2
_____	c. Administrative aircraft scheduled to fly within 6 hours.	3
_____	d. Primary mission aircraft within 6 hours of a scheduled flight.	4
_____	e. AGE for support of alert status.	

3. Write in the priority required for figure 1 of foldout 1, if the discrepancy was discovered 5 hours before flight of a primary mission aircraft by the ground crew.

068. Cite factors that influence the entries made in blocks 17 and 18 on an AFTO Form 349 and make required entries on an AFTO Form 349.

Time Specialist Required (Block 17). An entry in this block is required only when the AFTO Form 349

is used as a dispatch form. The time the work is scheduled to begin is entered. Job Control determines this time based on a number of factors, such as what type of maintenance you'll be performing, will other maintenance being performed delay you, and the length of time it will take you to complete your job. Arriving early at the job site is just as bad as arriving late. Any deviations from the required "show" time must be coordinated with Job Control.

The military 24-hour clock time system will be used to record the time. Rules for converting conventional time to the military 24-hour clock time system are as follows:

- Add a zero before the AM hours and remove the colon (:).
  Examples: 1:00 AM converts to 0100 hours; 9:20 AM converts to 0920 hours.
- Add 1200 to the PM hours and remove the colon.
  Examples: 1:00 PM converts to 1300 hours; 9:20 PM converts to 2120 hours.

The exceptions to these rules are the hours between midnight and 1:00 AM and noon to 1:00 PM. The hour between midnight and 1:00 AM starts at 0001 (1 minute after midnight) to 0059 hours (1 minute before 1:00 AM). The hour between noon and 1:00 PM starts at 1201 (1 minute after noon) to 1259 hours (1 minute before 1:00 PM).

Job Standard (Block 18). A job standard is used in determining the approximate time required for a given job. The job standard states the number of men required and average clock hours required. The entry you'll record will indicate the average clock hours. Examples of the entries are: 2 hours (2.0); 2½ hours (2.5). Job Control uses these standards in scheduling work within the maintenance complex.

Deficiency analysis develops job standards. Job standards are only developed for those standard and repetitive tasks for which a standard is needed as a management tool. An example would be the time allowed for the airframe portion of a periodic inspection. Job standards are developed from performance data which is combined with task time measurement or other investigative factors to establish a standard. Performance averages are used as a basis for investigations.

Exercises (068):

1. When is an entry placed in the time specialist required block on an AFTO Form 349?

2. List some factors that are considered in setting the time specialist required?

3. What is a job standard, as it relates to an AFTO Form 349?

4. Record in the proper block, in figure 1 of foldout 1, the entries for a "show time" of 9:30 AM and the average completion time of 3 hours.

069. Identify factors that influence the entry in block 26 on the AFTO Form 349.

Discrepancy (Block 26). This entry is a brief description of the trouble. The verbal description must agree with all other coded entries on the AFTO Form 349, such as the block C and F entries (work unit code and how malfunctioned code), and must be brief but accurate. An invalid entry in this block will result in an invalid input into the maintenance system.

Enter the following discrepancy in figure 1 of foldout 1; "Bracket Assy. on the main landing gear retracting mechanism cracked." We'll use this to develop the documentation for figure 1 of foldout 1, located in back of this volume.

Exercises (069):

1. What influence do blocks C and F of an AFTO Form 349 have on the entry made in block 26 of an AFTO Form 349?

2. What type of entry must be made in block 26 of an AFTO Form 349?

070. Point out the information that is entered into the Corrective Action block on the AFTO Form 349.

From this point on, our discussion shifts to the entries made after the job is completed. The previous entries are usually on the form when you receive it. How well you fill in the following entries determines value of this form for maintenance data collection purposes.

Block 27, Corrective Action. Enter a brief, but specific, description of the work accomplished to correct the discrepancy. This is the first entry you'll make after completing the job. Column D is directly related to the entry you make in this block. Both of these entries must correspond to each other to provide an ac-

curate input into Maintenance Data Collection System.

It is a good practice to enter the technical order that was followed to accomplish the job. References to specific pages and figures in the technical order should be used when a specific repair instruction is given in the repair manual. For purposes of our discussion, write in the following corrective action for the discrepancy shown in figure 1 of foldout 1, "Installed reinforcing patch on the main landing gear retracting mechanism bracket IAW (in accordance with) TO 1C-130A-3." Block 30, on the reverse of the form provides additional space for entries in blocks 26 and 27. This space is provided for situations when more than one maintenance action is recorded on AFTO Form 349.

Exercises (070):

1. Would the entries "complied with" and "fixed" be acceptable in block 27 of an AFTO Form 349? Explain your answer.

2. What is the title of the column that must indicate the same maintenance you accomplished in block 27?

3. When is block 30 used?

071. Indicate the factors that determine the entries in columns A, B, and C on the AFTO Form 349, and record required entries.

Before proceeding into the individual column entries, one term must be covered—action line entry. This refers to a complete line of column entries from column A to N. There are five action line entries on each AFTO Form 349. The column at the left of column A lists the numbering sequence for the action line entries. Look at figure 1, foldout 1, noting the position of this column.

Column A, Type Maintenance. The type maintenance code consists of one character and is used to identify the type of work that was accomplished, such as scheduled and unscheduled maintenance. This code, along with other data, is punched on cards that can be "read" by electronic data processing machines. The cards are processed periodically to produce reports for use in the management of the maintenance complex. Figure 2 of foldout 1, is a listing of the types of maintenance codes taken from a work unit code manual.

Column B, Component Position. The component position code is a 1-digit numerical character and is used to identify the position of the installed engine. For instance, if work is performed on No. 4 engine of a C-5, column B would have the entry of the number 4. An entry is required when installing, removing, or working on an installed engine. For all other maintenance actions leave this block blank.

Column C, Work Unit Code. The work unit code consists of five characters and is used to identify the system, subsystem, and component on which maintenance was accomplished. These codes are published in work unit code manuals for each weapon and support system, and certain types of equipment. A work unit code manual for an A model C-130 aircraft would be numbered T0 1C-130A-06.

The first two characters of the work unit code identify the system on which the maintenance was accomplished. The flight control system would be such a system. The third and fourth characters identify a subsystem (unit) of the system identified by the first two characters. A rudder would be the subsystem of the flight control system. The fifth character pinpoints the actual item repaired within the system. The trailing edge section of a rudder would be the actual item repaired in the flight control system. The work unit code 14114 is constructed as follows:

14 — identifies system - flight controls.
11 — indicates subsystem - rudder Assy.
4 — specific item - trailing edge section.

Figure 3 of foldout 1, is a portion of the work unit codes related to the landing gear system for a C-130A aircraft.

Exercises (071):

1. What is meant by the term "type of maintenance"?

2. Indicate in column A, figure 1 of foldout 1, the type maintenance code required.

3. Why is column B, figure 1 of foldout 1, left blank in this situation?

4. Using the information given in figure 3 of foldout 1, construct and record in column C the necessary work unit code.

072. Identify the entries for columns D, E, and F on a given AFTO Form 349.

Column D, Action Taken. This code identifies the action taken to correct the discrepancy indicated in block 26—in other words, "what you did to repair the item." The action taken codes contain one number or letter and are listed in the work unit code manual (-06) for the aircraft on which you performed maintenance. Figure 4 of foldout 1, is a sectional portion of the action taken codes listed in the -06 code manual.

Column E, When Discovered. This code identifies the operational condition at the time the deficiency or maintenance requirement was discovered. The when discovered code contains only one character. These codes are listed in the -06 code manual. Figure 5 of foldout 1, shows situations when maintenance discrepancies are likely to be found.

Column F, How Malfunctioned. This code consists of three characters and is used to identify the cause of the discrepancy. Two methods of locating the correct how malfunctioned codes are provided in the -06 code manual. Figure 6 of foldout 1, illustrates the alphabetical listing for how malfunctioned codes. An additional list, sequenced by how malfunctioned code numbers, is the other method.

Exercises (072):

1. Referring to figure 1 on foldout 1, write in the action taken, when discovered, and how malfunctioned codes required. Use figures 4, 5, and 6, on foldout 1, to locate the required coding indicators. NOTE: Ground crew found the discrepancy. Use figures 4, 5, and 6 on foldout 1, to answer the following questions:

2. When would the how malfunctioned code 780 be used?

3. When is the action taken code F used?

4. What is the when discovered code for isochronal inspections?

073. Determine the number to be entered in the Units block on an AFTO Form 349.

Column G, Units. This block represents units of work completed. A unit of work is a job that has a definite beginning and end, such as a periodic inspection or a completed repair. If you assist another work center in this job, but do not complete the job yourself, you must enter "0" in the Units block of your AF Form 349. This prevents falsely reporting more than one job on this item. In other words, when people from two or more workcenters work on the same job or the same piece of equipment, each workcenter must fill out a separate AFTO Form 349, but only one of these forms can reflect a unit of work completed. The last action line entry will indicate the "unit produced," regardless of the crew sizes or category of labor. If more than one form is needed to record the maintenance action, the last action line entry on the second form will indicate the unit produced. All other action line entries will show 0 units.

Exercises (073):

1. Six specialists from your shop help another shop to complete a job, taking all day. How many units do you enter on the AFTO Form 349?

2. Your entire organization, comprised of eight shops, must work together on a unit of work. How many AFTO Forms 349 must be completed and what is entered in the Units block on each one?

3. What is the required number of units for column G, in figure 1 of foldout 1, if your shop was the only one involved in correcting the discrepancy?

074. Distinguish between the entries for man-hour reporting on AFTO Form 349.

Entries required for columns A through G dealt in one way or another with the item being repaired. Columns H, I, J, and K are all used to account for the time and personnel it took to repair the item.

Column H, Start Hour. The start entry always reflects the starting time of the individual or crew completing the job. The hour of the starting time should be entered to the nearest 5 minutes. Since the 24-hour military clock time is used, you must enter four digits in this column. Apply the rules used to convert conventional time to the military 24-hour clock time system when making this entry.

Column I, Stop-Day/Hour. The stop time entry shows when you stopped working on the job. You

must annotate this column when the job is completed or when there is a delay or work stoppage that exceeds 15 minutes. At this time, you must close out (complete) the action line entry. If later you complete the job, you must fill out blocks A through N on the next action line. Enter the Julian day (the numbered day of the year) and hour to the nearest 5 minutes using the 24-hour clock system.

Column J, Crew Size. This entry shows the number of individuals who actually participated in the maintenance action. When workers are added to or removed from a job, that action line entry must be closed out and a new action line entry initiated to show the new number of workers on the job. Keep in mind that until the job is completed, zero units of work are recorded in column G. The column G entry cannot reflect units completed until the job is done. The maximum crew size that can be shown on a single action line is nine. For maintenance actions requiring more than nine people, another action line must be completed.

Column K, Category of Labor. This column is used to differentiate between the types of man-hours used. If all members of the work crew are the same category of labor, only one action line entry is required. If more than one category of labor is performing the same repair task, or if overtime man-hours are involved, separate action line entries are required to show the regular and overtime man-hours for each category of labor. The following are the codes used to identify the categories of labor:

Categories of Labor	*Codes*
Military, regular duty hours	1
Military, overtime hours	2
Federal service employee—regular duty hours	3
Federal service employee—overtime hours	4
Local national employee hours	5
Contractor labor hours	6

Exercises (074):
Record your answers to the following questions in figure 1 of foldout 1, in the correct columns.

1. What would be the start hour if you started working at 9:35 AM?

2. If the job was completed at 1:30 PM, with an hour lunch break from 11:30 AM to 12:30 PM, what entries would have to be made in columns G, H and I?

3. If, during the first 2 hours, you worked by yourself, and after lunch you are assigned to another job, and a Federal service employee completes the job you started in the morning, what entries are necessary in columns J and K?

4. How many action line entries are required to show the complete history of the work order?

075. Indicate the purpose and use of columns L, M, and N on the AFTO Form 349, and make entries in these columns from given information.

Command/Activity Identification, Column L. The column is used when maintenance is performed on transient aircraft and equipment with no I.D. number assigned. The two-position command code of the owning command is entered in this block. For all other maintenance tasks this block is optional and may be used to identify special projects, tenant support, or other actions such as for detached maintenance locations that return data to the home station for processing.

Schedule Code, Column M. When recurring maintenance, such as special inspections and maintenance, are accomplished on items based on the date last accomplished (DLA), an "X" must be entered in column M on the same line which contains the "unit produced" in column G. This action will automatically update the next scheduled required maintenance date. When performing routine maintenance on these items and not accomplishing the scheduled maintenance action, this column is left blank.

Employee Number, Column N. The employee number is a 5-character identifier used to identify the individual who has corrected the discrepancy. The first character is the first letter of the individual's last name. The last four characters are normally the last 4 digits of the individual's social security account number (SSAN).

When two or more people from the same workcenter are involved in a maintenance action, the employee number of the team supervisor or senior man will be recorded in column N. For bases under the Maintenance Management Information and Control System (MMICS), the employee number is assigned by a computer program of the administrative subsystem. This employee number is unique and will be used for documenting maintenance action.

Exercises (075):
1. What type of code is used in column L?

2. What is the purpose of column M?

3. Record the necessary entries in columns L, M and N, figure 1 of foldout 1, based on the following information:
Both SSgt Jones, FR137 32 8934, and Mr. Smith, SSAN 125 86 6136, (equal to an A1C rank) had a hand in correcting the discrepancy. Smith completed the job. Their base is *not* under the MMICS System, and the aircraft that was repaired is assigned to their base.

076. State the purpose of an AFTO Form 350 and record documentation on an AFTO Form 350.

AFTO Form 350. In our earlier discussion of the AFTO Form 349, the documentation recorded was developed from maintenance accomplished at the aircraft. The next maintenance data collection form, the AFTO Form 350, Reparable Item Processing Tag, is used when an item is removed from the aircraft and routed to the maintenance shop for repair. You'll use the entries on the AFTO Form 350 to develop documentation in accounting for time you spent in the shop repairing the item.

The first part of our discussion concentrates on the entries made by the individual removing the item from the aircraft. You must assure that these entries are on the form when the item is received in the shop, so that you can develop your time accounting documentation (AFTO Form 349). The second portion of our discussion centers on the actual entries required in accounting for your repair time using the AFTO Form 349.

Let's examine the entries made when the item is removed from the aircraft and briefly trace the sequence of events prior to the item's reaching the maintenance shop.

Figure 4-7 is an AFTO Form 350, Reparable Item Processing Tag. This form assures that the status of the reparable item is always identified and provides a source document for information required in completing other maintenance data documents. Also, it provides a means of controlling the flow of items to and from the maintenance shops.

Going back to the repair situation discussed for maintenance at the aircraft, let's change it. Upon arriving at the aircraft, you find that the "retracting mechanism bracket assembly" cannot be repaired at the aircraft. You inform the crew chief and then return to the shop. It is at this point that we'll pick up the sequence of events for discussing the use of the AFTO Form 350.

Step I. The crew chief removes the bracket assembly from the aircraft. It is at this time that an AFTO Form 350 is initiated. Blocks 1 through 14 are normally filled in, depending on the maintenance situation. For sake of our discussion, a supply request will not be made, so block 13 will be omitted. Also, an entry is made in block 29, on the back side of Part II of the AFTO Form 350, indicating the date the item was removed from the aircraft. Looking at figure 4-7, you'll see that most of the block entries are similar to those on the AFTO Form 349. So that you'll have an understanding of what entries are required, only those not covered already will be covered.

Block 6, MDS. This entry is the mission, design, and series, or end item work unit code. An example entry would be C-130A. This indicates the design, series, and model aircraft from which the repair part was removed.

Block 8, Item Oper. Time. The only time an entry is required in this block is when the item is a time change item or an item for which time records are maintained.

Block 10, FSC. This entry requires the first four digits of the Federal Supply Class code for the item being removed.

Block 11, Part Number. The part number of the item being removed, including dashes and slashes, is entered in this block. The manufacturer's part number or the complete identification number as it appears on the item's data plate is preferred. For items that do not have a part number, the last nine characters of the national stock number of the item are entered.

Block 12, Serial Number. This entry is directly related to the entry made in block 8. The serial number of the time change and serially controlled items have their serial number entered in the block. An asterisk is used to identify serially controlled items and time change items in the work unit code manual (-06).

Block 13, Supply Document Number. A 14-digit supply document number is entered here when a demand has been placed on the supply system.

Step II. After the required entries are made on Part I, the upper portion of the AFTO Form 350, the form is attached to the item and processed through the reparable processing center (RPC).

Step III. Prior to processing the item to the maintenance shop, the RPC monitor will:

a. Remove Part II, the lower portion, of the AFTO Form 350, for purposes of establishing and maintaining a control file.

b. Verify and, when necessary, correct the entries in blocks 10 and 11.

c. Fill in blocks 16 through 22 and indicate in block 29 the date received and date item was forwarded to the maintenance shop.

d. Indicate the repair priority either through use of a stamp or some other method of identification.

Step IV. At this time, the item is processed into the maintenance shop for repair.

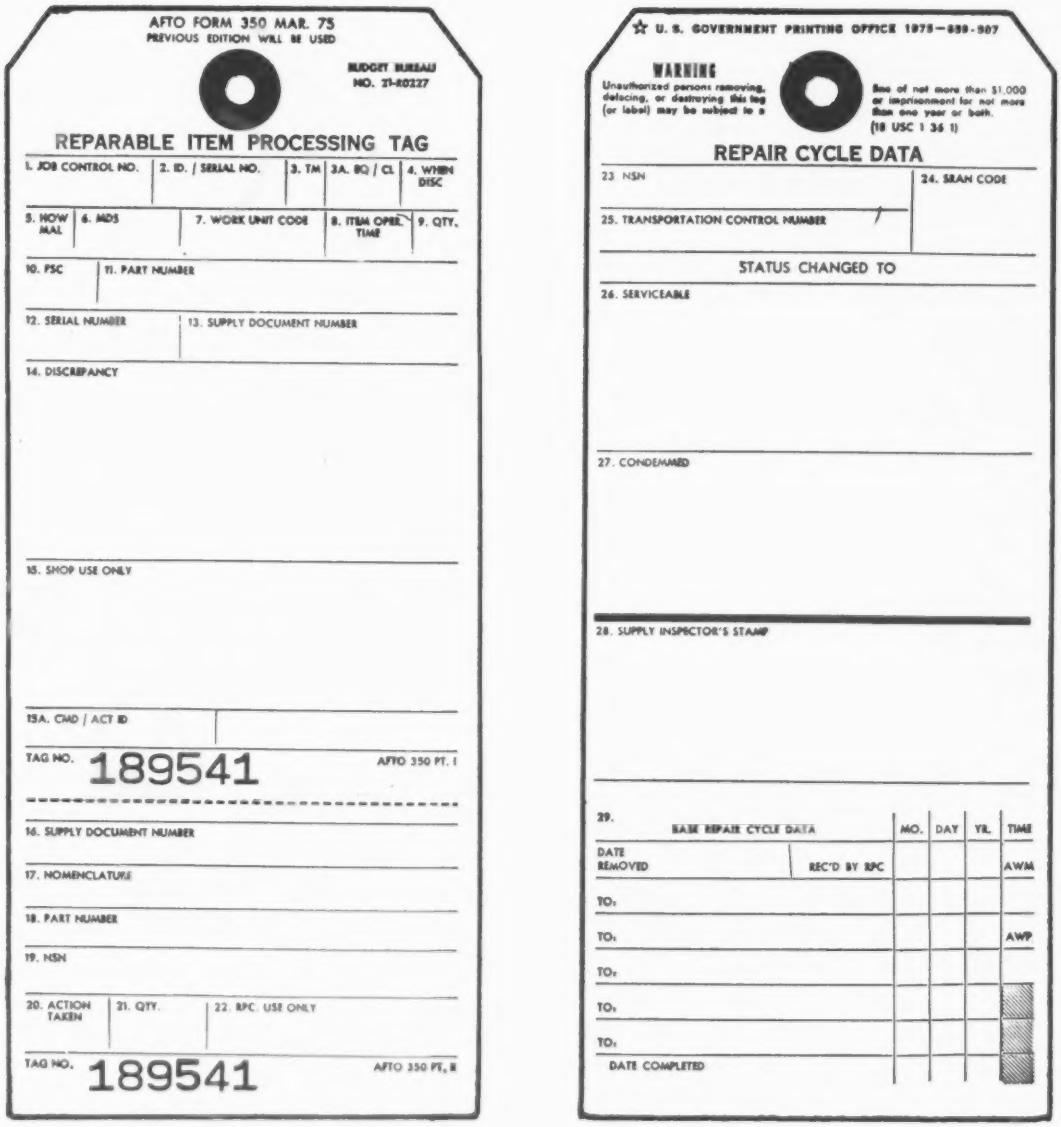

Figure 4-7. AFTO Form 350, Reparable Item Processing Tag.

Exercises (076):

1. Name three functions that are accomplished by using an AFTO Form 350.

2. Depending on the maintenance situation, what blocks are filled-out on the front side of Part I of an AFTO Form 350 by the individual removing the item from the aircraft?

3. Fill in the necessary entries in figure 4-7 required for processing "the retracting mechanism bracket assy" to the repair shop. Use the information given in figure 1, foldout 1, plus the additional data provided below to make the required entries.
   Additional data: a. National stock number—1560-00-954-0311.
   b. Part number—35678-1A.
   c. Item is not a time change item.

077. Develop the documentation for initiating an AFTO Form 349 for time accounting purposes based on data recorded on an AFTO Form 350.

After an item is made serviceable by repairs accomplished in the shop and prior to returning the item to the aircraft, an AFTO Form 349 must be initiated. The purpose of this is to account for the time you spent in repairing the item.

The entries on the AFTO Form 349 for recording "in-shop maintenance" and those required in recording maintenance "on the aircraft" are somewhat different. The main source of information for initiating the AFTO Form 349 is taken directly off the documentation on the AFTO Form 350 attached to the repair item. The remaining information you must provide. Figure 4-8 illustrates the required entries in accounting for "in-shop" maintenance. The differences between this AFTO Form 349 and the one shown in figure 1 of foldout 1, is the addition of two new entries, blocks 19 and 20, the elimination of the entries in blocks 17 and 18, and the use of a different "Action Taken Code (A)." The "Action Taken Code (A)" indicates that the item was "Bench Checked and Repaired."

The last step before returning the item to the aircraft is to make sure the AFTO Form 350 is attached to the item and that blocks 15 and 26 are completed. In block 15 enter a brief description of the work accomplished in correcting the discrepancy. Enter the date and your signature in block 26.

Exercises (077):

1. What is the primary source of documentation data for AFTO Form 349 used to record in-shop maintenance?

2. Fill in the required entries for accounting "in-shop" maintenance on figure 4-9. Use the data recorded in figure 4-7 and the following information to make the necessary entries. The priority 2 item was received in the shop at 2:30 PM, 16 January 1975, and completed at 4:30 PM. The crew size consisted of one military personnel, Sgt John Johnson, FR 196671374. The shop is *not* under the MMICS system.

3. Make the required entries on the AFTO Form 350, in figure 4-7, after the item has been repaired and being returned to the aircraft.

078. Prepare an AFTO Form 349 indicating the documentation required to account for productive indirect labor man-hours.

The last category of documentation using the maintenance data collection form, AFTO Form 349, is the

MAINTENANCE DATA COLLECTION RECORD — OMB NO. 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. EQ/CL	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
0300050	93130	AA3414				2		

10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD.

19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME
1560	667542-1B					

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N EMPLOYEE NUMBER
1	B		1411A	A	F	190	1	0730	030	0945	1	1			F8934
2															
3															
4															
5															

26. DISCREPANCY: Lower skin on trailing edge section of Rt. Aileron cracked

27. CORRECTIVE ACTION: Bench checked and repaired.

28. RECORDS ACTION

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Figure 4-8. AFTO Form 349, Maintenance Data Collection Record.

recording of productive indirect labor hours. The purpose of this documentation is to account for assigned maintenance man-hours used for functions when no maintenance is being accomplished. Documenting rules for recording productive indirect labor are outlined in T0 00–20–2 series technical orders.

Your supervisor is the originator of this form. He is responsible for reporting how the assigned man-hours are being used within his shop. Actual maintenance accounts for a large portion of these hours. The remaining hours must also be accounted for. All personnel assigned a direct labor (100 series) code must have a productive indirect labor report documented. A direct labor code of the 100 series is used only for nonsupervisors. A knowledge of this reporting system is necessary in that you, in the not-too-distant future, will be held responsible for the production of personnel working for you. How well you manage the time of your workers plays an important part in the success that you achieve as a supervisor.

Documentation. The entries required for documenting productive indirect man-hours are shown in figure 4-10. How each of these is developed is explained in the following description of the block entries.

Block 1, Job Control Number. The job control number is assigned by maintenance control for your particular work area. One job control number or a block of job control numbers could be assigned for a given period of time.

Block 2, Workcenter. Your shop workcenter code is entered in this block. This is the same workcenter code used to record maintenance.

Block 3, I.D. No./Serial No. The I.D. No./Serial No. entered in this block consists of the first position of your workcenter code followed by the letters INDLB. If the first position of your workcenter code were the letter Q, the correct I.D. No./Serial No. would be QINDLB.

Column C, Work Unit Code. Unique work unit codes have been developed to reflect the type of productive indirect labor being reported. These codes are listed in aircraft and associated equipment –06 technical orders. The following basic codes are currently in use:

Work Unit Code	*Description*
ALT00	Alert duty.
CMP00	Compensatory time for overtime.
DTL00	Details, squadron, or base duties.
LVE00	Leave.
TRN00	Maintenance training.

The last two numerical positions (00) may be assigned, as required by major command or below, to additional indicators to further identify the type of productive indirect labor. For example, "LVE01" could be used for ordinary leave while "LVE02" could be used for sick leave.

MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21–R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. EQ/CL	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD.
19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER			25. OPER. TIME

ACT LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCN CODE	N EMPLOYEE NUMBER
1															
2															
3															
4															
5															

26. DISCREPANCY

27. CORRECTIVE ACTION

28. RECORDS ACTION

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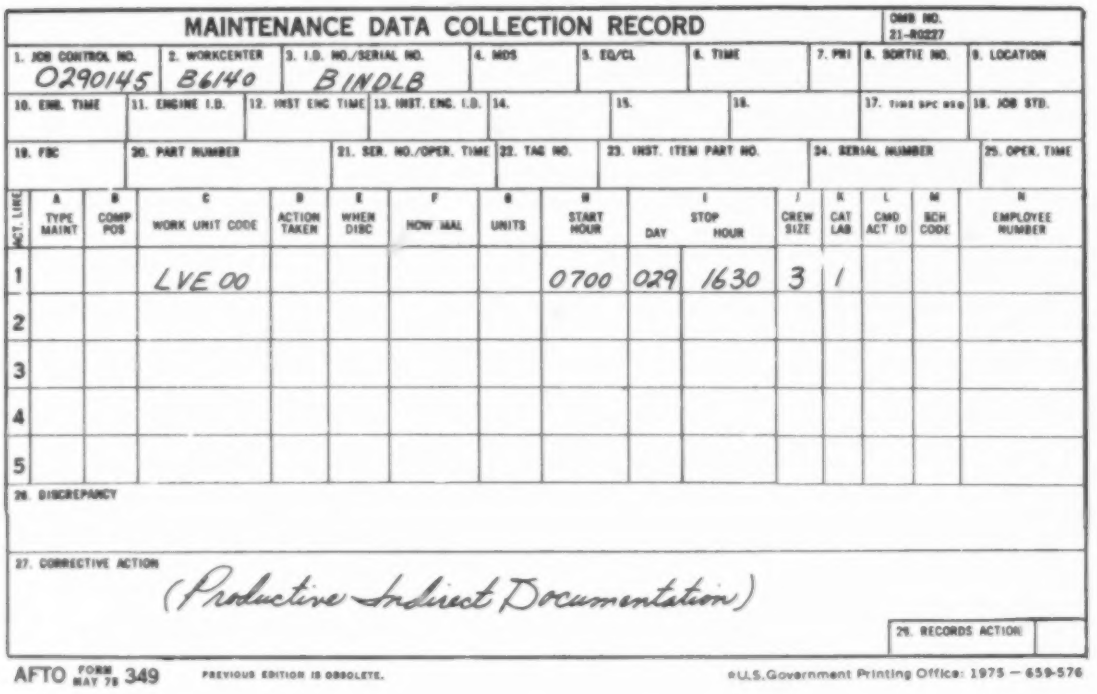
Figure 4-9. Objective 077, exercise 2.



MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. EQ/CL	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
0290145	B6140	BINDLB						

10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD.

19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M BCH CODE	N EMPLOYEE NUMBER
1			LVE 00					0700	029	1630	3	1			
2															
3															
4															
5															

26. DISCREPANCY

27. CORRECTIVE ACTION (Productive Indirect Documentation)

28. RECORDS ACTION

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Figure 4-10. Documentation for productive indirect man-hours.

Column H, Start Hour. Enter the hour (24-hour clock) to the nearest 5 minutes that productive indirect labor was started. For leave and compensatory time for overtime, the start time will always be during normal duty hours.

Column I, Stop Day-Hour. Enter the Julian day (001-366) and hour (24-hour clock) to the nearest 5 minutes that the productive indirect labor was terminated. This entry will always be during normal duty hours.

Column J, Crew Size. Enter the number of personnel, of the same category of labor, involved in the productive indirect tasks.

Column K, Category of Labor. Enter the category of labor which reflects the status of the individual involved. Each individual category of labor requires a different action line.

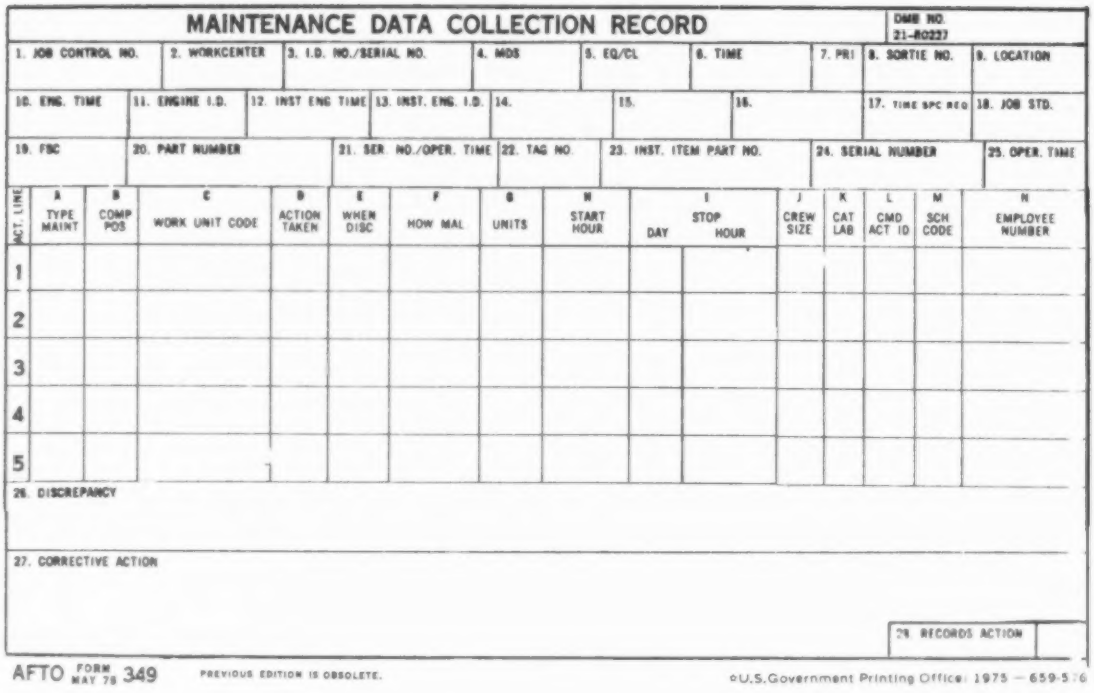
Exercise (078):

1. Fill in the necessary entries in figure 4-11 to reflect productive indirect labor man-hours used in the following situation:
   "An airframe repair specialist had 3 military personnel on squadron duty for 2 hours (from 1:00 PM to 3:00 PM), plus one Federal service civilian employee was off for 4 hours (12:30 PM to 4:30 PM) compensatory time for overtime. These personnel are not supervisors. The date is the 15th of January, and job control assignment number indicates that Job Control made 29 prior assignments. The workcenter for the airframe repair shop is A3130.

079. State the purpose of the USAF materiel deficiency reporting and investigating system, and diferentiate between the types of categories and method of reporting.

One of the benefits obtained through the Maintenance Data Collection System is the discovery of equipment deficiencies. Recurring defects and repeated maintenance on a specific piece of equipment are quickly identified. This identification makes it possible for engineering and technical agencies to make improvements through modification programs. Also, reports are developed and sent to other Air Force installations, so that similar deficiencies can be corrected on like equipment. T0 00-350-54, *USAF Materiel Deficiency Reporting and Investigating System,* outlines the procedures to follow when a deficiency is discovered.

USAF Materiel Deficiency Reporting and Investigating System. The basic purpose of this system is to establish methods that will feed back deficiency data to activities responsible for development, procure-



MAINTENANCE DATA COLLECTION RECORD

DMB NO. 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. EQ/CL	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION

10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD.

19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N EMPLOYEE NUMBER
1															
2															
3															
4															
5															

26. DISCREPANCY

27. CORRECTIVE ACTION

28. RECORDS ACTION

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Figure 4-11. Objective 078, exercise 1.

ment, and other logistics management functions so that action can be initiated to correct and prevent materiel, design and quality deficiencies. The procedures of this system apply to all USAF agencies, including depot level maintenance facilities, civil contractors, and Air Force test and evaluation teams or forces. This includes subsidiary or affiliated agencies for which USAF has support responsibilities, such as: Air Force Reserve (AFRES), Air National Guard (ANG).

The responsibility for clearance and control of materiel deficiency reports prescribed in T0 00-35D-54 is assigned to the quality control staff in accordance with AFM 66-1. Activities that are not governed by AFM 66-1 will establish a clearance and control office patterned after the quality control organizations prescribed in AFM 66-1. The organization that is responsible for the clearance and control of materiel deficiency reports will assign report control numbers to all materiel deficiency reports. They will maintain AF Form 2423, Technical Order Improvement or Unsatisfactory Materiel Report Log, for recording Category I and Category II reports. Report control numbers will be assigned in numerical sequence regardless of the type report submitted.

The person discovering the deficiency will prepare, process, and route materiel deficiency reports as prescribed in T0 00-35D-54. The Chief of Maintenance of the submitting activity will review all materiel deficiency reports prior to submittal to insure that they are reported under the correct method and are routed correctly. Emphasis will be placed on identification of materiel deficiencies which will be the subject of Category I reports to insure that only true safety conditions are reported as Category I.

Categories of Deficiencies. Different categories of deficiency reports have been developed to indicate the seriousness and effect it has on the operational efficiency of a unit. Presently, two categories are in use; Category I reports, and Category II reports.

Category I report. The Category I report is a report of emergency conditions of a safety nature on all types of equipment. These conditions are defined as follows:

(1) Accident or Incident—An unexpected or unsought event that does damage, or could cause damage, to persons or property and is not caused by enemy action.

(2) Nuclear Safety Deficiency—Any materiel, engineering, or procedural deficiency which could cause (or contribute to) a nuclear accident, incident, or deficiency.

(3) Critical Safety Deficiency—Malfunction of a part, component, or installation which results in an unacceptable hazard that requires corrective action be initiated as soon as possible for personnel and system survival.

(a) For aircraft, any materiel or installation deficiency that results in an inflight requirement to use prescribed emergency procedures or other extra-

ordinary means to avert further damage or injury to personnel should be reported by Category I. This requirement specifically includes, but is not limited to, flameout or engine failure of any engine, or significant loss of thrust or power, during the takeoff, landing approach, or go-around phases of flight. Category I reports are not required when corrective action for an inflight system failure or malfunction of a backup system.

(b) For missiles, any materiel or installation deficiency requiring identically equipped missiles possessed by the submitting activity to be inspected for the same deficiency will be submitted as a Category I report. If the same deficiency is evident in other missiles, certain restrictions must be imposed to lessen the degree of risk involved.

(c) For equipment other than aircraft or missile, materiel, or installation deficiencies which require that the affected equipment be withheld from use will be reported as a Category I report. A critical safety deficiency on CEM equipment is any malfunction, design deficiency, or equipment (including safety devices) which could result in exposure of maintenance and operating personnel to lethal voltages, excessive radiation, or other potential danger by either direct or indirect action.

(4) Explosive Safety Deficiency—A deficiency or condition presenting a known or suspected hazard to personnel and equipment through malfunction, inadvertent functioning, and detonation of ammunition or explosives during use, handling, or storage.

Category II report. The Category II report is a report of:

(1) Nonwork unit coded (WUC) items with design and maintenance materiel deficiencies which do not have a safety impact, but the uncorrected existence of which would, through prolonged usage:

(a) Constitute a hazard.

(b) Have a negative effect on operational efficiency.

(c) Reduce tactical or tactical support ability.

(d) Reduce operational life or general service utilization of equipment.

(e) Create economic burdens (manpower and money). Category II reportable conditions embody degrees of risk or requirements calculated to be tolerable within broad time limits.

(2) Quality deficiencies in materiel which are attributable to nonconformance to applicable specifications, drawings, standards, technical order, errors in workmanship, failure to provide or account for all specific parts or other conditions that can be traced to nonconformance during manufacture, repair, modification, or maintenance.

Method of Reporting. Category I reports will be submitted by electrical transmission on DD Form 173, Joint Messageform. These reports will generate investigation projects which demand the highest priority available at the action and support points, and in the case of grounding action or the removal from service of like items, will require continuous (around the clock) action for resolution.

Category II reports will be submitted by AUTODIN, using Standard Form 368 format to report those deficiencies.

Exercises (079):

1. What is the purpose of the USAF materiel deficiency reporting and investigating system?

2. In the space provided in front of each statement indicate whether a statement is Category I or Category II by inserting the required number.

_____ a. Deficiency that could cause a nuclear incident.

_____ b. Uncorrected deficiency reduces tactical support ability.

_____ c. Deficiency creates an economic burden on the unit.

_____ d. Deficiency resulting from errors in workmanship.

_____ e. Inflight deficiency that is not corrected by a backup system.

_____ f. A missile deficiency requiring similar items of equipment be inspected.

_____ g. Deficiency traced to nonconformance during modification.

_____ h. Inadvertent functioning of ammunitions.

_____ i. Deficiency requires that equipment be withheld from use.

_____ j. Deficiency has a negative effect on operational efficiency.

3. What method is used to report Category I reports?

4. What method is used to report Category II reports?

080. Point out ways to improve local maintenance procedures.

Maintenance Training. By consulting the maintenance data collection reports, you, the supervisor, can discover the tasks that are taking too many man-hours to accomplish. From your past experience, you know the number of hours normally required for each of these tasks. If only a few tasks appear to be taking too long, you may overlook them. But if you notice several such tasks coded to one system, you can see that there is need for more training. Additional training can decrease the number of man-hours involved.

Records. One of the most useful records at squadron level for improving work methods is the AFTO Form 95, Significant Historical Data. This is a record of the past history of aircraft or equipment and can be used to analyze their past malfunctions. An analysis of this report can give you an insight to a problem area, and you can determine the action to correct it.

Reports. Other reports can help you improve your work methods. The deficiency reports previously discussed can help you in evaluating your current practices. Don't just complete the required action and file the report. Study it! It can be the key to better methods.

Exercises (080):

1. What use can be made of a deficiency report?

2. What specific record is useful in analyzing past aircraft malfunctions?

3. Name the source material that can identify a need for additional training.

Technical Order System

THERE ARE TWO ways of doing things—the right way and the wrong way. Both ways cost the Air Force millions of dollars each year. The "right way" cost is attributed to the developing, testing, and publishing of the correct procedures to follow in maintaining the Air Force's equipment. The "wrong way" cost is attributed to the loss of equipment through the failure to follow the "right way" of accomplishing maintenance. Based on the following actual incident, decide for yourself which "way" was followed.

While the pilot was taxiing the T-39 he discovered the rudder binding at full rudder travel. The aircraft was returned to the parking area, where it was found that a bolt that had been used to attach bonding wire to the upper rudder support had worn a hole through the rudder surface. The bolt caught on the edge of the hole. The item manager was contacted for proper hardware to be used for attaching bonding wire. The proper hardware was a rivet.

This incident could have been avoided. Fortunately, this problem was discovered on the ground. No telling what would have happened if this would have occurred in the air.

As a member of the maintenance team, your "way," and only way, is the "right way"—using technical order procedures. The term "tech data" is the *watchword* by which the Air Force maintains its equipment.

5-1. Technical Order System

Many types of publications are used in the Air Force. One category—standard publications—includes regulations, manuals, pamphlets, and supplements:

a. Regulations announce policies, assign responsibilities, and direct actions.

b. Manuals detail instructions, procedures, and techniques.

c. Pamphlets contain information.

d. Supplements are auxiliary publications for local compliance with directives.

You have probably used most of these already. As standard publications, they should not be confused with technical publications, also called technical orders (TOs).

The technical order system is the official means used to distribute military orders of a technical nature to the authorized using activities. These publications, called technical orders, contain information, instructions, and safety procedures pertaining to the inspection, operation, maintenance, and modification of Air Force equipment and material.

In this section, we will discuss the purpose and scope of technical orders. From there we'll turn our attention to the different types of TOs, the numbering system used for identification, and research procedures related to indexes. Lastly, we'll cover how to keep TOs current and how to report TO deficiencies.

In a later volume, procedures for locating information in different technical orders for specific repair procedures will be covered.

081. State the purpose of technical orders and indicate their scope as to authority, content, and compliance responsibilities.

Purpose and Scope. Technical orders are official Air Force publications that provide technical information, instructions, and safety procedures pertaining to the operation, maintenance, and modification of Air Force equipment and material. They are intended to insure the performance of the mission with the greatest possibility for success and the least chance for loss of life or damage to equipment. AFR 8-2, *Air Force Technical Order (TO) System,* leaves no doubt that weapon systems must be operated and maintained by the use of technical orders.

Simply stated, a technical order is a military order that must be followed until it is rescinded or modified by proper authority.

The following two paragraphs have been taken from T0 00-5-1, *AF Technical Order System.*

Concept. The TO system is the medium used to disseminate military orders of a technical nature. Each individually numbered TO provides the technical information and instructions to operate, install, maintain, inspect, or modify Air Force systems and equipment items. The TOs are published under authority of the Secretary of the Air Force in accordance with AFR 8-2 and distributed and filed in accordance with TO 00-5-2, *Technical Order Distribution System.*

Compliance. Compliance with Air Force TOs is mandatory. Technical order instructions play a critical

role in achieving system and equipment readiness. Major commands will insure that activities under their jurisdiction are aware of the need for full compliance, effective use, and economical operation of the TO system.

To receive the full benefits of TOs, you must be familiar with the technical order system. This is why your supervisor and everyone connected with maintenance stress the use of tech data. Any change in the technical data that you are using will be brought to your attention. The importance of following TO instructions *cannot* be overstressed.

Exercises (081):

1. State the purpose of technical orders.

2. What document authorizes the operation and maintenance of weapon systems by the use of technical orders?

3. What information is contained in technical orders?

4. Identify the Air Force publication with which technical order files must comply.

5. What responsibility does every individual have concerning TOs?

082. Identify the various types of technical orders in terms of purpose, content, and/or use.

Types of Technical Orders. Of all the different types of technical orders, these five are the most important to you:

- Indexes.
- Technical Manuals.
- Methods and procedures.
- Abbreviated TOs.
- TCTOs.

A brief description of each of these follows.

Indexes. Index type technical orders provide you with a means of selecting and locating a needed TO. There are several types of TO indexes. Our discussion later in this chapter, will pertain to only two: the numerical index and requirement table (NI & RT) and the alphabetical index. All indexes are identified by the number zero (0) in the first part of the TO number.

Technical manuals. Technical manuals contain detailed instructions for operation, maintenance, service, overhaul, installation, and inspection. They are grouped into main categories covering aircraft, missiles, special weapons, and other equipment.

Methods and procedures technical orders. Methods and procedures technical orders are general and do not deal with specific aircraft or equipment. They are divided into two classes: (1) those that involve policies, methods, and procedures in maintenance management or administration; and (2) those that give policies, methods, and procedures relating to equipment in general. TOs of this type always start with double zeros (00).

Abbreviated technical orders. These TOs are primarily work simplification devices. They are condensed versions of other TOs. Included in this group are inspection workcards, sequence charts, and checklists.

a. Inspection workcards. Inspection workcards prescribe minimum inspection requirements and are used during inspections.

b. Inspection sequence charts. These charts provide a planned work schedule or sequence so that the inspection workcards can be used effectively.

c. Checklists. Checklists give TO items in abbreviated form. They are used in performing various tasks or operations in a safe sequence. A checklist is identified by the letters "CL" followed by a digit at the end of a TO number.

Time compliance technical orders. TCTOs give instructions for inspections and operating procedures and for modifications of Air Force equipment within certain time limits. Immediate Action, Urgent Action, Routine Action, and Interim are the ones that most concern you.

Exercises (082):

Match the types of technical orders given in column B with statements given in column A.

Column A	*Column B*
_____ 1. Type of work simplification devices.	a. Indexes.
_____ 2. Type of TO that always starts with double zeros.	b. Manuals.
_____ 3. Type of TO that always starts with a single zero.	c. Methods and Procedures.
_____ 4. Contain detailed instructions for a specific type of equipment.	d. Abbreviated TOs.
_____ 5. Contain general information for various types of equipment.	e. TCTOs.
_____ 6. Describe minimum inspection requirements.	
_____ 7. Outline modification procedures.	
_____ 8. Provide a means of locating a specific TO.	
_____ 9. TOs are grouped into three main categories.	
_____ 10. Provide a planned or scheduled work sequence.	

083. Point out the purpose and key features of the numbering system used to categorize technical orders.

Numbering System. Each technical order has a number similar in purpose to your own social security number. This number distinguishes one technical order from another and provides a systematic grouping of technical publications. Each TO number is divided into three or more parts, separated by dashes. The meaning of each part depends on the category of technical order and the number of parts in the TO number. Figure 5-1 is a partial list of the categories used for technical orders.

As an airframe repairman, most of your work with technical order concerns the repair of aircraft and maintenance of special tools and shop equipment. With this in mind, our discussion on the TO numbering system will be centered on these areas.

Category I, Aircraft Technical Orders. This technical order number for aircraft category TOs is divided into three or more parts, such as TO 1B-52G-3, and TO 1F-4C-3-1-1.

Part one. The first part consists of a number designator identifying the TO category plus a letter designa-

TO CATEGORY	TITLE
0	Numerical Index and Requirements Tables, Numerical Index, Alphabetical Indexes, and Cross Reference Table Technical Orders
00	General Technical Orders
1	Aircraft Technical Orders
2	Airborne Engine Technical Orders
3	Aircraft Propellers and Associated Equipment Technical Orders
4	Aircraft Landing Gear Components and Associated Equipment Technical Orders
5	Airborne Instrument Technical Orders
6	Aircraft and Missile Fuel Systems and Equipment Technical Orders
31	Electronic Technical Orders
32	Standard and Special Tools Technical Orders
33	General Purpose Test and Associated Equipment Technical Orders
34	Shop Machinery and Associated Equipment Technical Orders
35	Ground Handling, Support and Base Operating Equipment Technical Orders
36	Vehicles, Construction and Materials Handling Equipment and Equipment and Components Technical Orders
37	Fuel, Oil, Propellant Handling and Associated Equipment Technical Orders

Figure 5-1. Technical order categories.

tor identifying the type of aircraft. Here are a few examples:

- 1 — Applied to all aircraft.
- 1A — Attack aircraft.
- 1B — Bomber aircraft.
- 1C — Cargo aircraft.
- 1F — Fighter aircraft.
- 1H — Helicopter aircraft.
- 1T — Trainer aircraft.

Part two. The second part identifies the aircraft model, series, and configuration or identifies a general TO if the second part is the number "1". Design changes altering the functional use of an aircraft or designation of a special use is identified by letters in parentheses. Special configuration is identified by a Roman numeral in parentheses. Here are some examples:

- 1B-1 — Bomber Aircraft-General TOs.
- 1C-47A — Cargo Aircraft, Model 47, Series A.
- 1B-52A — Bomber Aircraft, Model 52, Series A.
- 1F-100D(I) — Fighter Aircraft, Model 100, Series D, Configuration I.

Part three. When a technical order number has only three parts, the third part identifies the operational and procedural TOs related to the specific aircraft identified in part two. Figure 5-2 is a partial list of the 37 different types of operational and procedural technical orders presently in use. Numbers from 38 to 100 have been reserved for future use.

For general aircraft technical orders, the third part identifies an individual TO number. The General Engineering Manuals, such as TO 1-1A-1 through TO 1-1A-14, are examples of general technical orders.

Part four. When a TO number has four parts, the third part identifies both the kind of TO and individual TO, while the fourth part identifies a section of the sectionalized TO. In the TO number 1B-58A-1-1, the first -1 indicates flight manual and the second -1 identifies a section of the flight manual.

Part five. When a TO number has five parts, the third part identifies the kind of TO, the fourth part identifies an individual TO, and the fifth part identifies a section of the sectionalized TO. In the TO number 1F-4C-3-1-1, the -3 indicates that it is a Structural Repair Manual, the first -1 identifies the individual TO, and the second -1 identifies a section of the sectionalized TO, in this case—general information.

Category 34 Shop Machinery. In this category, the meaning of the individual parts of a technical order number have a different meaning because shop equipment is involved.

Part one. The first part normally consists of three designators.

- The first designator is numerical and identifies the TO category.

  Example: 34—Shop Machinery and Component TOs.

- The second designator is alphabetical and identifies a major group of equipment within the category.

  Examples: 34C—Cutting Machines.
  34G—Forming Machines.

- The third designator is numerical and identifies a specific type of equipment within the major group identified by the second designator.

  Examples: 34C2—Metal Cutting Machines.
  34G1—Metal Forming Machine.

Part two. The second part of the TO number identifies a general technical order series of an equipment type, model, or part number, when the TO number has only thee parts.

Examples: 34G1-1, Metal Forming Machines—General
34Y1-155, Part Number 100-871-11

Part three. When the TO number has only three parts, the third part identifies the kind of TO. The kind of TO is based on the number itself. The following is a listing of the kinds of TOs and the numbering system. Note that each last number within each group is the same.

- List of Applicable Publications—01.
- Service or Maintenance Instruction—2, 12, 22 through 492.
- Overhaul Instruction—3, 13, 23 through 493.

```
        -01 List of Applicable Publications
            (LOAP) Unit
06 thru -09 Work Unit Code Manual
         -1 Flight Manual
         -2 Maintenance Instructions
         -3 Structural Repair Instructions
         -4 Parts Catalog
         -5 Basic Weight Check List and
            Loading Data
         -6 Inspection Requirements
         -7 Winterization Instructions
         -8 Checkout Manuals
         -9 Cargo Loading
        -10 Power Package Build-Up Instructions
        -11 Power Package Build-Up Instructions
        -12 Maintenance Materiel Management
            Manual
        -13 Weapons Loading Manual
        -14 Atomic Loading and In-Flight
        -15 Assembly, Test and Storage
            Procedures
        -16 Atomic Loading and In-Flight (See
            0-1-11N)
        -17 Storage of Aircraft
        -18 Field Maintenance of Airborne
            Materiel
        -19 Conversion Instructions
        -20 Reserved
        -21 Aircraft Inventory Record Master
            Guide
        -22 Reserved
        -23 Corrosion Control
        -24 Reserved
        -25 Air Crew Weapon Delivery Manuals
            (See TO 0-1-11N)
        -26 Air Crew Weapon Delivery Manuals
            (See TO 0-1-11N)
```

Figure 5-2. Operational and procedural TOs.

- **Part Catalog or illustrated Parts Breakdown (IPB)—4, 14, 24 through 494.**
- **Inspection Requirements—6, 16, 26 through 496.**
- **Installation Instructions—7, 17, 27 through 497.**
- **Checkout Manuals, Checkout and/or Programmed Texts—8, -18, 28 through 498.**
- **Time Compliance Technical Order (TCTO)—501 and higher**

Here is an example of a four-part TO number.

Example: 34Y1-155-1

TO Category	34
Major Group of Equipment	Y
Specific Type of Major Group	1
General Series, Type Model, or Part Number	-155
Kind of TO	-1

Part four. When the TO number has four parts:

- The second part identifies the specific item of equipment type, model, or part number.
- The third part identifies a general series, or equipment type, model, or part number.
- The fourth part identifies the kind of TO.

Example: 34F2-2-125-1

TO Category	34
Major Group of Equipment	F
Specific Type of Major Group	2
Specific Item	-2
General Series, Type, Model, or Part Number	-125
Kind of TO	-1

Exercises (083):

1. What is the purpose of a technical order number?

2. What factors determine the meaning of the individual parts of a technical order number?

3. What is meant by the term "kind of TO"?

4. What is the structural repair TO for a fighter type aircraft, series 109, Model B? Use the smallest TO number that would indicate this.

5. In the space provided in front of each item listed below, identify the specific part of the TO number 34B4-3-2-1 by placing the number or letter which corresponds to the item description.

_____ a. Kind of technical order.

_____ b. Category of technical order.

_____ c. General series.

_____ d. Specific type of equipment.

_____ e. Major group of equipment.

_____ f. Specific type of major group.

5-2. Technical Order Application

Being able to locate specific information in a technical order is the *key* to using technical orders. Not being able to locate information is the big excuse people use for not using technical orders. Don't be trapped in this situation. With a basic knowledge of the technical order system and initiative on your part, you will be able to locate the information you need.

Our discussion starts off at the very "heart" of the TO system—the indexes. These provide the gateway to all the information available in Air Force technical orders.

084. Using an example of numerical index, isolate specified information.

Numerical Index. There are 50 categories of technical orders in use today, with various types and kinds of technical orders within each category. The number that you'll use is small compared to the total number of TOs. Occasionally, you will have to use a technical order that is new or one that you ordinarily don't use. This is when indexes are necessary. They provide a quick and accurate source of information concerning the location of information for a specific category of aircraft and equipment contained in the various technical orders.

Features. Figure 5-3 is the first page of TO 0-1-01,

PART I
NEW AND REVISED
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TECHNICAL ORDERS

NUMERICAL INDEX AND REQUIREMENT TABLES

***	0-1-01 (U)	NUMERICAL INDEX AND REQUIREMENT TABLES, NUMERICAL INDEX, ALPHABETICAL INDEX, AND CROSS REFERENCE TABLE TECHNICAL ORDERS	12 NOV 75	OC
	0-1-02 (U)	GEN TECHNICAL ORDERS	6 SEP 75	OC
	0-1-02C	SUPPL - TITLE SAME AS BASIC	8 OCT 75	OC
	0-1-1-1 (U)	GEN ACFT TECHNICAL ORDERS	1 MAY 75	OC
	0-1-1-1C	SUPPL - TITLE SAME AS BASIC	8 OCT 75	OC
	0-1-1-2 (U)	BOMBER ACFT TECHNICAL ORDERS	1 MAY 75	OC
	0-1-1-2C	SUPPL - TITLE SAME AS BASIC	8 OCT 75	OC
***	0-1-1-3 (U)	CARGO AND SPECIAL ELECTRONIC ACFT TECHNICAL ORDERS	9 OCT 75	OC
	0-1-1-4 (U)	FIGHTER ACFT TECHNICAL ORDERS	6 SEP 75	OC
	0-1-1-4C	SUPPL - TITLE SAME AS BASIC	8 OCT 75	OC
***	0-1-1-5 (U)	ATTACK, HELICOPTER, OBSERVATION, ANTI- SUBMARINE, TRAINER AND UTIL ACFT TECHNICAL ORDERS	9 OCT 75	OC
	0-1-2-1 (U)	GEN AIRBORNE ENG TECHNICAL ORDERS	30 AUG 75	OC
***	0-1-2-1D	SUPPL - TITLE SAME AS BASIC	31 OCT 75	OC
	0-1-2-2 (U)	JET ENG AND ASSOCIATED EQUIP TECHNICAL ORDERS	30 AUG 75	OC
***	0-1-2-2D	SUPPL - TITLE SAME AS BASIC	31 OCT 75	OC
	0-1-2-3 (U)	BOOSTER AND ROCKET ENG AND ASSOCIATED EQUIP TECHNICAL ORDERS	30 AUG 75	OC
***	0-1-2-3D	SUPPL - TITLE SAME AS BASIC	31 OCT 75	OC
	0-1-2-4 (U)	GAS TURBINE ENG AND ASSOCIATED EQUIP TECHNICAL ORDERS	30 AUG 75	OC
***	0-1-2-4D	SUPPL - TITLE SAME AS BASIC	31 OCT 75	OC
	0-1-2-5 (U)	RECIPROCATING ENG AND ASSOCIATED EQUIP TECHNICAL ORDERS	30 AUG 75	OC
***	0-1-2-5D	SUPPL - TITLE SAME AS BASIC	31 OCT 75	OC
	0-1-3 (U)	ACFT PROP AND ASSOCIATED EQUIP TECHNICAL ORDERS	28 JUN 75	OC
***	0-1-3C	SUPPL - TITLE SAME AS BASIC	31 OCT 75	OC
	0-1-4 (U)	ACFT LANDING GEAR COMPONENTS AND ASSOCIATED EQUIP TECHNICAL ORDERS	28 JUN 75	OC
***	0-1-4F	SUPPL - TITLE SAME AS BASIC	31 OCT 75	OC
***	0-1-5-1 (U)	AIRBORNE INSTRUMENTS TECHNICAL ORDERS	9 OCT 75	OC
	0-1-5-2 (U)	AUTOMATIC CONTROL SYS, FLT INSTRUMENTS AND ASSOCIATED EQUIP TECHNICAL ORDERS - DATE WAS INADVERTENTLY OMITTED. IT SHOULD BE 8 MAY 75	8 MAY 75 TPS 100, 11 JUL 75	OC

L-1

Figure 5-3. TO 0-1-01, Numerical Index and Requirement Tables.

Numerical Index and Requirement Tables TO 0-1-01 is the *index of indexes,* and is actually composed of a series of NI&RTs. Each separate NI&RT contains a ist of publications applicable to a specific category of equipment.

Let's use TO 0-1-01. Refer to figure 5-3 as we discuss each column. The first column (where the asterisks are located) is additional publication information indicated by a symbol, identified in the preface of the TO. The second column gives the TO number with the security clearance beneath it. The indicators are: U—Unclassified, C—Confidential, and S—Secret. The third column shows the title of the publication and more explicit security information. Column four gives the printing date. The last column shows the Air Logistics Center (ALC) with storage and issue responsibility. These listings are also found in the preface.

The preface of each NI&RT contains information applicable to the specific category covered therein. The meaning of symbols and the TO numbering system used for a particular NI&RT are the types of information found in the preface.

Research procedures. Suppose you need a TO that contains information on the Maintenance Data Collection System. Since maintenance data does not apply to a specific aircraft or piece of equipment, but rather it applies to many different items, this information would be contained in a general type TO. Refer to figure 5-3, TO 0-1-01, *Numerical Index and Requirement Tables,* and you see that NI&RT 0-1-02 lists the general TOs. Now look at TO 0-1-02, figure 5-4, under the heading of Maintenance Management System—General. Find a TO with the title "The Maintenance Data Collection System." The identifying number for this TO is 00-20-2. It is unclassified, its effective date was 1 July 75, it hasn't been changed since its basic date, and the responsible ALC is OC (Oklahoma City).

Exercises (084):

Refer to figures 5-3 and 5-4 as necessary to answer the following questions:

1. What is the latest change data and the security classification for TO 00-20-1?

2. Give the title and responsible ALC for TO 00-20-2-4.

3. Give the title for TO 0-1-1-4C.

4. The printing date of TO 0-1-2-3 is _____.

085. Show how an alphabetical index is used in locating a specific technical order.

Alphabetical Index. The alphabetical index, TO 0-2-1, provides an easy method for locating the correct TO group when the type of equipment is known. Figure 5-5 is a page taken from TO 0-2-1. Under each alphabetical heading is an alphabetical listing of the items and partial TO numbers (first part) of the items related to the heading. Some items used as subitems under a main heading are main headings themselves in other sections. This provides a cross-reference source for further information research.

This TO does not give you the status of the individual publications. The only authorized source for determining the status and availability of individual publications is part 1 of the appropriate numerical index. The last three pages of this TO list a cross-reference of categories to specific NI&RT. Note in figure 5-6 that some of the categories have been sectionalized.

The more you know about an item, the easier it will be to research information. Such things as model number, manufacturer's name, whether it is operated by air pressure or electricity, and what the item is used for, are helpful aids in finding information. With this in mind, let's follow the sequence of events in locating a specific TO for a specific piece of equipment.

You are given the job of fixing a broken contour metal cutting saw in your shop. After inspecting the saw you determine that a replacement part must be ordered. The only information that you're able to obtain off the saw is the model number—Model 36-2M (Do-all). With this information, your first step is to look in TO 0-2-1, *Alphabetical Index.* But what do you look under—Shop Machinery, Saws, or Contour Metal Cutting Saw? A sure bet is shop machinery, for the item is a piece of shop equipment. Figure 5-7 shows the alphabetical listing for shop machinery and associated equipment. Looking down the list, you come to Metal Cutting Machine—34C2. This is the category for *all* metal cutting machines.

Now that we know the category, we can proceed to the next step—locating the specific NI&RT index. Adding 0-1 to the category, designators of the first part of the technical order, gives you the index to go to the next TO, 0-1-34. Figure 5-8 is the table of contents for NI&RT 0-1-34. Using the TO numbers located in TO 0-2-1, look at the listing until you find the specific type of metal cutting machine saws. An additional number is added to our original number in this step. Our TO number now is 34C2-8.

Figure 5-9 is a page out of the section given in the table of contents for saws. At this point, the information you have obtained off the machine itself comes into play, particularly the model number—Model 36-2M (Do-All). Going down the listing of titles and content descriptions, you will come to Contour Sawing Machine, Model 36-2M (Do-All). Under this heading are listed three technical orders. The first one

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NEW AND REVISED
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TECHNICAL ORDERS

GENERAL TECHNICAL ORDERS

TECHNICAL ORDERS SYSTEM – GENERAL

00-5-1 (U)	AF TECHNICAL ORDER SYSTEM	15 NOV 73 CHG 1, 20 SEP 74	OC
00-5-2 (U)	TECHNICAL ORDER DISTRIBUTION SYS	20 AUG 73 CHG 1, 15 FEB 74	OC
00-5-15 (U)	AIR FORCE TIME COMPLIANCE TO SYS	1 JUN 71	OO

MAINTENANCE MANAGEMENT SYSTEM – GENERAL

00-20-1 (U)	PREVENTIVE MAINT PROGRAM, GEN REQUIREMENTS AND PROCEDURES	15 JAN 74 CHG 1, 1 JUN 74	OC
00-20-2 (U)	THE MAINTENANCE DATA COLLECTION SYSTEM	1 JUL 75	OC
00-20-2-2 (U)	ON-EQUIP MAINT DOCUMENTATION FOR ACFT AIR LAUNCHED MISSILES, GROUND LAUNCHED MISSILES, EXCEPT ICBMS, DRONES, AND RELATED TRAINING EQUIP	1 JUL 75	OC
00-20-2-4 (U)	MAINT DOCUMENTATION FOR IN-SHOP ENG MAINT	1 JUL 75	OC
00-20-2-5 (U)	ON-EQUIP MAINT DOCUMENTATION FOR INTERCONTINENTAL BALLISTIC MISSILES – LGM25•LGM30	1 JUL 75	OC
00-20-2-6 (U)	ON-EQUIP MAINT DOCUMENTATION FOR NUCLEAR WEAPONS, REENTRY VEHICLES AND REENTRY SYS, AND RELATED TEST AND HANDLING EQUIP	1 JUL 75	OC
00-20-2-7 (U)	ON-EQUIP MAINT DOCUMENTATION FOR AGE, TRAINERS AND SIMULATORS	1 JUL 75	OC
00-20-2-8 (U)	ON-EQUIP MAINT DOCUMENTATION FOR GROUND COMMUNICATIONS-ELECTRONICS-METEOROLOGICAL EQUIP	1 JUL 75	OC
00-20-2-10 (U)	OFF-EQUIP MAINT DOCUMENTATION FOR SHOP WORK, CONVENTIONAL MUNITIONS, AND PRECISION MEASUREMENT EQUIP	1 JUL 75	OC
00-20-2-13 (U)	AFLC DEPOT OFF EQUIP MAINT DOCUMENTATION	1 JUL 75	OC
00-20-3 (U)	MAINT PROCESSING OF REPARABLE PROPERTY AND REPAIR CYCLE ASSET CONTROL SYS	1 JUN 73 CHG 1, 15 JAN 74	OC
00-20-4 (U)	CONFIGURATION MANAGEMENT SYS	1 JUN 73 CHG 2, 1 AUG 75	OC
00-20-5 (U)	ACFT, DRONE AND AIR LAUNCHED MISSILE INSPECTIONS, FLT REPORTS, AND SUPPORTING MAINT DOCUMENTS	1 JUL 75	OC
00-20-6 (U)	INSPECTION SYS, DOCUMENTATION, AND STATUS REPORTING FOR GROUND-LAUNCHED MISSILES AND THEIR TRAINERS AGE AND GROUND CEM EQUIP	15 JUL 75	OC
00-20-7 (U)	INSP SYS, DOCUMENTATION, AND STATUS REPORTING FOR AGE AND TRAINING EQUIP (EXCLUDING GROUND-LAUNCHED MISSILES) – F5B,E	15 APR 75 CHG 1, 12 JUN 75	OC
00-20-8 (U)	INSPECTION SYS, DOCUMENTATION, AND REPORTING FOR GROUND COMMUNICATIONS-ELECTRONICS-METEOROLOGICAL (CEM) EQUIP (EXCLUDING GROUND CEM EQUIP USED IN DIRECT SUPPORT OF GROUND-LAUNCHED MISSILES)	1 JUN 73 CHG 1, 1 JUN 74	OC

Figure 5-4. TO 0-1-02, General Technical Orders.

T.O. 0-2-1

ABSORBERS
Air Conditioning and Pressurization Equipment 15A17
ACCELERATORS
Test Equipment, Associated 33AA37
ACCELEROMETERS
Automatic Control System 5A24
Automatic Control System 5A32-2
Bombing Systems and Equipment 11B63
Fire Control System 11F2
Flight Instruments 5F2
Gravity Drop, Fire Control 11F2-4
Guidance and Control System 11G14-4
Lateral Linear 5A24-2
Limiting 5A24-3
Navigation Instruments 5N9
Test Equipment, Automatic Flight Control . 33D3-21
Test Equipment, Guided Missiles 33D9-142
Voltage, Fire Control 11F2-3
ACCUMULATORS
Booster, Hydraulic 9H1-5
Cylindrical 9H1-2
Hydraulic, Missile Support 35M21
Hydraulic System 9H1
Missile Support Equipment 35M21
Pneumatic, Missile Support 35M21-3
Pneumatic System 9P14
Pressure, Pneumatic 9P1-3
Propulsion, Missile Support 35M21-4
Spherical 9H1-3
Test Equipment, Associated, Special Purpose 33DA76
Turbo Jet and Turbo-Prop Aircraft and Engine Fuel System 6J25
ACTUATORS
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Figure 5-5. TO 0-2-1, Alphabetical Index.

CROSS-REFERENCE OF CATEGORY TO NI&RT (AND TITLE)

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00	0-1-01	Numerical Index and Requirement Tables, Numerical Index, Alphabetical Indexes, and Cross Reference Tables Technical Orders
97	0-1-02	General Technical Orders
1	0-1-1-1	General Aircraft Technical Orders
1	0-1-1-2	Bomber Aircraft Technical Orders
1	0-1-1-3	Cargo Aircraft Technical Orders
1	0-1-1-4	Fighter Aircraft Technical Orders
1	0-1-1-5	Attack, Anti-Submarine, Helicopter, Observation, Trainer and Utility Aircraft Technical Orders
2	0-1-2-1	General Airborne Engine Technical Orders
2	0-1-2-2	Jet Engine and Associated Equipment Technical Orders
2	0-1-2-3	Booster and Rocket Engine and Associated Equipment Technical Orders
2	0-1-2-4	Gas Turbine Engine and Associated Equipment Technical Orders
2	0-1-2-5	Reciprocating Engine and Associated Equipment Technical Orders
3	0-1-3	Aircraft Propeller and Associated Equipment Technical Orders
4	0-1-4	Aircraft Landing Gear, Components and Associated Equipment Technical Orders
5	0-1-5-1	General Airborne Instrument Technical Orders
5	0-1-5-2	Automatic and Flight Control System and Associated Equipment Technical Orders
5	0-1-5-3	Engine and Temperature, Liquid-Level Quantity and Flow Measuring, Electric, Position and Pressure Instrument Technical Orders
5	0-1-5-4	Navigation Instrument Technical Orders
6	0-1-6-1	General Aircraft and Missile Fuel System and Equipment Technical Orders
6	0-1-6-2	Air Refueling System and Equipment Technical Orders
6	0-1-6-3	Turbo Jet and Turbo Prop Aircraft and Engine Fuel System and Equipment Technical Orders
6	0-1-6-4	Rocket Engine Fuel System and Purging System Technical Orders
6	0-1-6-5	Reciprocating Aircraft and Engine Fuel System and Offensive System Technical Orders
7	0-1-7	Airborne Engine Lubricating Systems and Associated Equipment Technical Orders
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8	0-1-8-3	Combination Alternating and Direct Current Electrical Equipment Technical Orders
8	0-1-8-4	Direct Current Electrical Equipment Technical Orders
8	0-1-8-5	Ignition System, Relays and Switches Technical Orders
9	0-1-9-1	General Airborne Hydraulic, Pneumatic and Vacuum System Technical Orders
9	0-1-9-2	Hydraulic System Technical Orders
9	0-1-9-3	Pneumatic and Vacuum System Technical Orders
10	0-1-10	Photographic Equipment, Supplies and Sensitized Materials Technical Orders
11	0-1-11-1	General Armament Technical Orders
11	0-1-11-2	Explosive Ordnance Disposal and Rendering Safe Procedure Technical Orders
11	0-1-11-3	Operation, Maintenance, Storage and Inspection (Specialized Munitions) Technical Orders
11	0-1-11-4	Ammunition, Explosives and Associated Equipment Technical Orders

Figure 5-6. TO 0-2-1, Cross-Reference of Category to NI&RT (and title).

T.O. 0-2-1

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Figure 5-7. TO 0-2-1, Shop Machinery and Associated Equipment.

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Figure 5-8. NI&RT TO 0-1-34, Table of Contents.

		MODELS ML, V-16, V-26, V-36, V-60		
	34C2-8-6-24 (U)	P/C -- CONTOUR METAL SAWING, FILLING AND POLISHING MACHINE, MODEL ML (CONTINENTAL)	10 NOV 50	WR
	34C2-8-6-44 (U)	P/C -- CONTOUR METAL SAWING, FILLING AND POLISHING MACHINE, MODEL V-36 (CONTINENTAL)	9 NOV 50	WR
N	34C2-8-6-54 (U)	ORG, FIELD AND DEPOT MAINT ALLOWANCES -- SAW, BAND (MACHINE) METAL CUTTING, VERTICAL 3/4 HP, 110 V, 60 CYCLE, (40-S-570) SINGLE-PHASE, MODEL DOALL ML (CONTINENTAL) (ORD 7-8, J-332 INCLUDING CL)	10 MAY 54	WR
E	34C2-8-6-62	OPR, MAINT INSTR -- BAND SAW, MACHINE SINGLE-PHASE, 60 CYCLE, 110-V, 3/4 HORSEPOWER, VERTICAL METAL-CUTTING (CONTINENTAL MODEL DOALL ML) (40-S570) -- (TM-9-9097-1)	2 JUL 54	WR
N	34C2-8-6-82 (U)	REBUILD STANDARD -- METAL CUTTING, BANK SAWING AND FILING MACHINE, MODEL DO ALL ML (40-S-570) (CONTINENTAL) -- (TB ORD 597-19)	16 AUG 55	WR
		MODEL 8		
N	34C2-8-10-11 (U)	OPR, ORG, FIELD MAINT INSTR -- 110/220V, SINGLE-PHASE, 60 CYCLE, AC, 1/2-HP 8 X 16 IN. CAPACITY CUTOFF BAND SAW (WELLS MODEL 8) -- (TM 9-9094-2 INCLUDING C1)	5 APR 56	WR
N	34C2-8-10-54 (U)	ORG, FIELD AND DEPOT MAINT REPAIR PARTS AND SPECIAL TOOL LISTS -- CUTOFF BAND SAW, 110/220-V, SINGLE PHASE, 60-C, 1/2 HP 8 X 16 INCH CAPACITY, MODEL 8 (WELLS) -- (TM 9-3419-205-25P)	1 JUN 62	WR
		MODEL B-10		
N	34C2-8-16-4 (U)	ORG, FIELD AND DEPOT MAINT ALLOWANCES -- TOOL ARMATURE TURNING AND UNDERCUTTING 115 V, 60 CYCLE, SINGLE-PHASE, (FRANK N. WOOD MODEL B-10) (40-T-225) -- (ORD 7-8, J-3 85, INCLUDING C1)	29 FEB 52	WR
		MODEL 30		
N	34C2-8-18-4 (U)	ORG, FIELD AND DEPOT MAINT ALLOWANCES -- TOOL, ARMATURE TURNING AND UNDERCUTTING, 115 V, 60 CYCLE, SINGLE-PHASE (DEVERE MODEL 30) (40-T-225) -- (ORD 7-8, J-486)	0 MAY 53	WR
		CONTOUR SAWING MACHINE, MODEL 36-2M (DOA11)		
	34C2-8-23-1 (U)	OPR, SVC INSTR	15 SEP 58	WR
	34C2-8-23-3 (U)	O/H INSTR	15 SEP 58	WR
	34C2-8-23-4 (U)	IPB	15 SEP 58	WR
		MODEL 36W, 36M		
	34C2-8-25-1 (U)	INSTR WITH P/B -- BAND SAW, MODEL 36W, -M (DOALL)	1 MAR 61	WR
		MODEL 2613-2HM		
N	34C2-8-26-1 (U)	OPR, MAINT INSTR -- SAW, METAL CUTTING, MODEL 2613-2HM, DBW-8 (DO ALL) (COMMERCIAL)	NOT DATED	WR
		MODEL HS		
N	34C2-8-27-1 (U)	INSTR WITH P/B -- BAND SAW, MODEL HS (JOHNSON) (COMMERCIAL)	NOT DATED	WR

Figure 5-9. NI&RT TO 0-1-34, Contour Saw Section.

is the operating and servicing instructions. The second one is for overhauling, and the last one is an illustrated parts breakdown. This is the one you need—TO 34C2-8-23-4.

Now it is just a matter of locating the part number you need in an illustrated parts breakdown technical order. Either a manufacturer's part number or national stock number will be given.

Exercises (085):

1. What would you use an alphabetical index to find?

2. How are NI&RT indexes developed from the information found in an alphabetical index?

3. How can you make your researching much easier?

4. Describe the sequence of researching a particular technical order for a specific piece of equipment of which you only know the name of the equipment.

086. Distinguish among the types of TCTOs in terms of classification factors, method of issuance, identifying symbols, and application.

Time Compliance Technical Orders. Earlier we briefly touched on TCTOs in describing the types of technical orders. Here we'll get into the types of TCTOs and factors that determine the classification of each type.

Immediate Action TCTO. An immediate action TCTO is issued when an unsafe condition exists, which, if uncorrected, could result in loss of life or damage to valuable property. This TCTO displays a border of red Xs around the outside edge of the title page and the words IMMEDIATE ACTION in red at the top. The red X is the symbol you enter in the maintenance forms of the equipment for which the TCTO is issued. This type of TCTO states that the work must be accomplished immediately upon receipt of the TCTO and/or kits, and the equipment grounded pending compliance. Immediate action TCTOs are automatically rescinded 6 months from the date of issue.

Urgent Action TCTO. An urgent action TCTO is issued because of a potentially hazardous condition, which, if uncorrected, could result in injury to personnel, damage to valuable property, or reduction of operational efficiency. This type of TCTO displays a border of circled red Xs around the outside edge of the title page, and the words "URGENT ACTION" are printed in red at the top. This type of TCTO specifies that the work must be accomplished within a specific time period, usually from 1 to 10 days. Failure to accomplish the work within the specified time period grounds the equipment. For example, you receive an urgent action TCTO, and the title page specifies that you have 6 days to accomplish the work. The symbol you enter on the maintenance forms is a red diagonal. If at the end of 6 days compliance is not accomplished, change the red diagonal to a circled red X, which grounds the equipment. Urgent action TCTOs are automatically rescinded 12 months from the date of issue.

Routine Action TCTO. These TCTOs are issued because of equipment or procedural discrepancies, which, if uncorrected, constitute a hazard through prolonged use, have a negative effect on operational efficiency, reduce the use of tactical or tactical support equipment, or reduce the operational life or use of general service equipment. This type of TCTO is printed on plain white paper without any distinguishing marks around the edge of the title page. The routine action TCTO is divided into two categories: category 1 and category 2. If the words "Routing Action" imply to you that this TCTO is not too important, take another look. By reading the following, you will discover that this is not the case; so let's discuss each category individually.

a. A routine action category 1 TCTO. These TCTOs specify that the work be accomplished by field and/or organizational maintenance. There are two types of category 1 TCTO actions: those that will be accomplished by a specified time and those that will be accomplished along with an event, such as the next scheduled inspection or when the equipment is removed from alert status.

b. A routine action category 2 TCTO. These TCTOs specify that the work be accomplished by the depot during depot-level maintenance, such as the next IRAN (inspect and repair as necessary), or overhaul.

Interim TCTO. An interim TCTO is an electrically transmitted message (TWX) and is usually issued for an IMMEDIATE ACTION or URGENT ACTION TCTO. This makes sense if you will think about it for a minute. It takes time to write, edit, publish, and distribute a TCTO. If the maintenance situation is serious enough to label a TCTO IMMEDIATE or URGENT ACTION, the work must be spread immediately. Hence, the interim TCTO. The interim TCTO contains all the necessary information for compliance: the TCTO number, type of TCTO, when the work is to be accomplished, by whom the work is to be accomplished, and the step-by-step instructions of how to accomplish the work. A formal TCTO replaces the interim TCTO within 10 work days.

Exercises (086):

1. What determines which type of TCTO is published?

2. How is an interim TCTO issued?

3. List the symbols used to identify the types of TCTOs.

4. What is the difference between a routine action category 1 TCTO and a routine action category 2 TCTO?

5. When is a red X entered in the aircraft maintenance forms (781A) for an Urgent Action TCTO?

087. Point out how TCTO kits are used and controlled.

TCTO Kits. Since some TCTOs require the use of TCTO kits, our coverage of TCTOs is not complete without a discussion of these kits.

Kit policies. Immediate action TCTOs are released upon determination of a requirement for a technical order. Release is not delayed pending availability of the kits.

Urgent action and routine action TCTOs are released upon availability of the first kits or parts. Kits are distributed to Air Force activities by priority. One copy of the applicable TCTO is packaged with each kit. These copies are identical to the same-dated copies distributed for files and, therefore, are completely authoritative for compliance. The format used for TCTOs is shown in figure 5-10. Little is left for misinterpretation. All areas of responsibilities are included.

Kit control. A technical order compliance control will be established by the Chief of Maintenance, preferably in the maintenance control section. They will administer the TCTO records and control of kit distribution as required by maintenance activities. Green colored AFTO Forms 349 may be used to identify maintenance actions accomplished relative to TCTOs.

Incomplete kits will be returned immediately upon determination of shortage to the TCTO control point. They, in-turn, contact supply for corrective action.

Exercises (087):

1. Who is responsible for establishing a control section to handle TCTOs within a maintenance organization?

2. Why are Immediate Action TCTOs not delayed because of nonavailability of kits?

3. What system is used to determine who receives TCTO kits first?

4. How are AFTO Forms 349 used for TCTO maintenance actions sometimes distinguished from other AFTO Forms 349?

5. What action should be taken if a part of a TCTO is missing?

5-3. Maintenance of Technical Orders

Maybe now someone else in your shop is keeping the technical order you use up-to-date and current. How well he performs this task has a direct effect on you. Technical orders not being current and up-to-date have been the "downfall" of many a maintenance man. Sooner or later you'll be in a position and have this duty assigned to you of keeping technical orders current.

088. Differentiate between the methods used to keep technical orders current and cite the method to use when issuing a supplement.

There are several methods used to maintain technical orders current and up-to-date. TO 00-5-1, Section IV, contains specific procedures associated with changes, revision supplements, appendixes, and rescission of publications. Each method is discussed separately in the following paragraphs.

Changes. Changes are issued when only parts of the existing TOs are affected. The changed pages replace the corresponding numbered pages, and all replaced pages must be removed from the TO and discarded or placed in the replaced pages file as applicable. If a change contains additional material that cannot be fully included on a single replacement page, additional pages are issued and inserted between or after the affected pages. Pages added between pages are assigned the preceding page number plus capital letter suffixes in consecutive order. Pages added after affected pages

HEADING ARRANGEMENT

1. APPLICATION.

2. PURPOSE.

3. WHEN TO BE ACCOMPLISHED.

4. BY WHOM TO BE ACCOMPLISHED.

5. WHAT IS REQUIRED.

   a. Supply Information and Requirements.

      (1) PARTS REQUIRED PER EQUIPMENT.
      (2) ACTION REQUIRED ON ITEMS IN STOCK.
      (3) PARTS REQUIRED TO MODIFY ITEMS IN STOCK.
      (4) DISPOSITION OF REMOVED AND REPLACED PARTS.
      (5) DRAWINGS REQUIRED.
      (6) SIZE, WEIGHT, AND COST OF PARTS KIT.
      (7) DISPOSITION OF KITS.

   b. Personnel Information and Requirements.

   c. Special Tools, Fixtures, Jigs and Test Equipment Required for Operational Test of Modified Equipment.

6. HOW WORK IS ACCOMPLISHED.

7. SUPPLEMENTAL INFORMATION.

   a. Operational Checkout Requirements.

   b. Technical Orders Affected.

8. RECORDS.

   a. Action On Maintenance Records.

   b. Action on Supply Records.

   c. Reidentification of Modified Items.

AUTHORITY

Figure 5-10. TCTO Format.

continue in numerical sequence, such as 2-4, 2-5 or 21, 22, depending upon the numbering system used in the technical order.

A new title page will be issued with each change. The new title page will bear the basic TO date as well as the change number and the date of the change. When a change to a TO includes previously issued supplements, a replacement notice will be included to indicate the TO number and the date of each supplement included in the technical order. Figure 5-11 is a title page reflecting changes.

Changed pages are identified by referring to the list of effective A pages which indicates the change numbers and/or change dates. Figure 5-12 illustrates a typical A page. On the page that is changed, the change number is printed in the lower corner of the changed page with the page number. Changes in the text of a technical nature, policy, procedures, or of a similar type are indicated by a heavy black line in the outer margin opposite the changed part of the text. Corrections of minor inaccuracies of a nontechnical nature, such as spelling and punctuation, will not be marked with a black line unless the corrections change the meaning of instructive information and procedures. Figure 5-13 shows areas on the original page where the changes took place.

T.O. 1C-135(K)A-3-1

TECHNICAL MANUAL

STRUCTURAL REPAIR INSTRUCTIONS

USAF SERIES

KC-135A
EC-135C (Formerly KC-135B)
C-135A
C-135B
RC-135A
RC-135C

AIRCRAFT

F04606-67-A-0619
F34601-75-D-0067

CHANGE NOTICE

LATEST CHANGED PAGES SUPERSEDE THE SAME PAGES OF PREVIOUS DATE

Insert changed pages into basic publication. Destroy superseded pages.

THIS CHANGE INCLUDES OPERATIONAL SUPPLEMENT T.O. 1C-135(K)A-3-1S-20 DATED 9 JANUARY 1975.

PUBLISHED UNDER AUTHORITY OF THE SECRETARY OF THE AIR FORCE

Air Force OC, 23 Jul 75-750

15 FEBRUARY 1962

CHANGE 52 - 15 JUNE 1975

Figure 5-11. Technical order title page.

LIST OF EFFECTIVE PAGES

INSERT LATEST CHANGED PAGES. DESTROY SUPERSEDED PAGES.

NOTE: On a changed page, the portion of the text affected by the latest change is indicated by a vertical line, or other change symbol, in the outer margin of the page. Changes to illustrations are indicated by miniature pointing hands. Changes to wiring diagrams are indicated by shaded areas.

Dates of issue for original and changed pages are:

Original . . . . 0 . . . . 15 May 75
Change . . . . 1 . . . . 15 Sep 75

Total number of pages in this publication is 1254, consisting of the following:

Page No.	* Change No.
Title	1
A	1
i	0
ii	1
iii — x	0
xi — xii	1
xii.1 Added	1
xii.2 Blank Added	1
xiii — xiv	1
xiv.1 Added	1
xiv.2 Blank Added	1
xv	1
xvi — xxiv	0
xxv	1
xxvi	0
1-1 — 1-119	0
1-120	1
1-120.1 Added	1
1-120.2 Blank Added	1
1-121 — 1-139	0
1-140 Blank	0
2-1 — 2-36	0
2-36.1 Added	1
2-36.2 Blank Added	1
2-37 — 2-162	0
3-1 — 3-76	0
4-1 — 4-2	1
4-3 — 4-10	0
4-10.1	1
4-10.2 Blank	1
4-11 — 4-15	0
4-16	1
4-16.1 Added	1
4-16.2 Blank Added	1
4-17 — 4-18	1
4-18.1 Added	1
4-18.2 Added	1
4-19 — 4-108	0
4-109	1
4-110	0
4-111	1
4-112 — 4-211	0
4-212	1
4-213 — 4-222	0
4-223	1
4-224	0
4-224.1 Added	1
4-224.2 Blank Added	1
4-225	1
4-226 — 4-245	0
4-246	1
4-246.1 Added	1
4-246.2 Blank Added	1
4-247 — 4-260	0
4-261	1
4-262	0
4-263 — 4-265	1
4-266 — 4-354	0
5-1 — 5-2	0
5-3 — 5-4	1
5-5 — 5-26	0
5-27	1
5-28 — 5-41	0
5-42 Blank	0
6-1 — 6-15	0
6-16	1
6-17 — 6-90	0
6-91	1
6-92 Blank	1
6-93	0
6-94 Blank	0
7-1 — 7-16	0
8-1 — 8-25	0
8-26 Blank	0
9-1	0
9-2 Blank	0
10-1	1
10-2	0
10-3 — 10-4	1
10-4.1 Added	1
10-4.2 Added	1
10-5 — 10-14	0
10-15 — 10-17	1
10-18 — 10-42	0
10-43 — 10-44	1
10-45 — 10-48	0
10-48.1 Added	1
10-48.2 Added	1
10-49	1
10-50 — 10-131	0
10-132	1
10-132.1 Added	1
10-132.2 Blank Added	1
10-133 — 10-155	0
10-156	1
10-156.1 Added	1
10-156.2 Added	1
10-157 — 10-162	0
10-163 — 10-164 Added	1
10-164.1 Added	1
10-164.2 Blank Added	1
10-165 — 10-168 Added	1
10-168.1 Added	1
10-168.2 Blank Added	1
10-169 — 10-176 Added	1
10-176.1 Added	1
10-176.2 Blank Added	1
10-177 — 10-180 Added	1
10-180.1 Added	1
10-180.2 Blank Added	1
10-181 — 10-183 Added	1
10-184 Blank Added	1
11-1 — 11-90	0
12-1 — 12-6	0

*Zero in this column indicates an original page.

Figure 5-12. Technical order "A" page—list of effective pages.

NOTE

Remove all organic coatings, except epoxy primer, Specification NAI-1269, and surfacer used on plastic laminate parts, with paint remover, Federal Specification TT-R-248 (or equivalent) or methyl ethyl ketone.

MATERIALS

COMMERCIAL STOCK NUMBER	NOMENCLATURE	SPECIFICATION OR STOCK NUMBER	PARTS BY VOLUME
–	Paint Remover	MIL-R-81294 or TT-R-248	–

a. Apply a heavy coat of paint remover, using a paintbrush or a bean sprayer. Never use an atomizing spray gun.

b. Allow paint remover to remain wet on the surface until evidence of softening or lifting of the coating is apparent.

NOTE

If dwell time in excess of two hours is required, an aeronautical materials and process engineer shall be consulted.

c. Mix paint remover and softened coating with a stiff bristle brush while paint remover is wet.

CAUTION

Limit air and water pressure to that which will not damage parts being processed.

d. Remove loose and softened coating with high pressure water, an air and water rinser, squeegee, or disposable cloth.

e. For aluminum and magnesium, aluminum wool or a plastic scraper may be used on softened but tightly adhered coating. Never use steel wool, a steel putty knife, or other metal scraper on aluminum or magnesium.

f. For ferrous alloys, steel wool or a plastic scraper may be used on softened but tightly adhered coatings.

g. Use a stiff bristle brush, such as a stencil brush, for detailing areas such as skin joints and fasteners.

h. Rinse thoroughly with clean water and dry. Clean cloths wet with water may be used when other rinsing methods are not feasible.

i. Mask around affected areas approximately 1 inch beyond edge.

j. Taper paint edges to a featheredge, using No. 320 wet-or-dry abrasive sheet.

1-135. Difficult to Remove Coatings – Some resin systems, such as epoxy and polyurethane, are not readily removed by chemical paint removers and may require several applications of paint remover, with dwell times of an hour or more after applications.

NOTE

If a dwell time in excess of 2 hours is required, an aeronautical materials and process engineer shall be consulted.

Figure 5-13. Technical order pages—marginal indicators (changes).

Technical Order Page Supplement (TOPS) A TOPS (fig. 5-14) is different from a standard change in that a TOPS page supplements rather than replaces an individual page in a technical order. It is also different from a supplement because an individual TOPS page is filed in the TO facing the affected TO page. Technical order page supplements are stored and issued like changes but are replaced like supplements. The TOPS will be printed on green paper to distinguish them from standard changes. They are issued only when the requirement for issuing the data does not meet the criteria for safety or operational supplements, the reproducible copy or negatives for the TO are not available for use in preparing a standard page, or time and circumstances do not permit issuing a standard change.

The TO number of a TOPS is the same as the basic TO. Each TOPS is identified by a TOPS number and date printed under the basic TO date on the TOPS title page. Technical order page supplements for each TO are numbered sequentially, starting with the number 100, such as 101-13 February 1973. The number used to identify a TOPS for a TO will not be reused to identify a new TOPS for that TO for 1 year after the original TOPS has been superseded.

Revisions. A revision is a complete new edition of an existing TO and has a new basic date. It includes existing changes and replaces any supplements listed in the replacement note on the title page. Normally, a TO is revised when the pages affected by existing changes, in addition to pages requiring change, total 80 percent or more of the TO. The determination of the need for a revision is also based on factors such as the impact of changes and supplements on the usability of the TO, urgency of need for change, cost, quantity of stock on hand, and the existence of reprint incorporating (merging) existing changes. Black vertical borderline symbols indicate current changes in the text of a revision which were not previously published as TO changes or supplements.

Appendixes. An appendix is used to include material in a TO that is not part of the normal sequence outlined in the table of contents, such as tables and charts. Such added material becomes an integral part of the affected TO.

An appendix may be issued either as part of the basic TO or subsequent to the issuance of the basic TO. An appendix is issued when it is desired to include additional information in an existing TO. In this event, the appendix is issued with a change title page, and the pages of the appendix are then inserted at the end of the basic TO.

Recission. Technical orders are rescinded for Air Force use when the information is no longer required, is incorporated in other publications, or the recission date indicated in TCTOs has expired. Some TOs are rescindsed for Air Force use but are retained in stock for Military Assistance Program (MAP) use. These TOs are listed in a separate Numerical Index and Requirements Table. Publications will not be removed from the files until listed as rescinded in the Numerical Index and Requirements Table.

Supplements. Supplements are issued as separate TOs to add to or to change data in the basic TO. Supplements are of two types: cumulative and noncumulative. A cumulative supplement includes all the information contained in previously issued supplements and therefore replaces them. Read the title page to see if any supplements are included in the cumulative supplement. Remove from the TO file any supplements included in the cumulative supplement. Noncumlative supplements do not contain any previously issued supplements and replace only those items listed on the title page.

Supplements have the same TO number as the TOs that they supplement except that the supplement has a letter added to the end of the TO number. The word "SUPPLEMENT" is printed in heavy black type at the top of the title page.

Safety supplements. These supplements are used as a quick way to distribute safety information correcting a TO deficiency. By this we mean that the TO, if followed as written, constitutes a hazard. The information contained in the safety supplement is incorporated in the original TO at the next revision of the TO. When this takes place, the title page of the revision or change states that the safety supplement has been included and the safety supplement is to be removed from the file.

Like other supplements, safety supplements have the same TO number as the TO they supplement. The letters "SS" are added to the TO number to identify the publication as a safety supplement. The last number in the safety supplement number indicates the number of that supplement. For example: the first safety supplement to TO 1F-106A-1 would be TO 1F-106A-1-SS-1; the second safety supplement would be TO 1F-106A-1-SS-2; and the third would be TO 1F-106A-1-SS-3.

Operational supplements. These supplements are issued as a quick way to reflect information when work stoppages or operational defects related to the accomplishment of the mission are involved. The information contained in operational supplements is incorporated in the original TO when the original TO is revised or changed. Operational supplements are numbered the same way that safety supplements are numbered except that the operational supplement uses a single letter "S" rather than the double "SS". The reason for not using "OS" is that the "O" might be read as a zero instead of the letter.

Methods of Issuing Supplements. Safety and operational supplements are issued two ways: interim and formal. Interim supplements are issued by electrical transmission to the headquarters of the using commands. The headquarters passes the information on to all affected activities of the command. Interim safety supplements are issued when safety conditions exist which result in fatal or serious injury to personnel, or when extensive damage or destruction of property or equipment is involved. Interim operational supplements are issued to correct conditions when the using

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OCAMA TECHNICAL ORDER PAGE SUPPLEMENT (TOPS) CHANGES WILL BE NUMBERED CONSECUTIVELY BEGINNING WITH CHANGE 500 TO PREVENT CONFLICT WITH REGULAR CHANGE NUMBERING.

THESE PAGES ARE FOR INSERTION ONLY.
THEY DO NOT REPLACE EXISTING WHITE PAGES.

PUBLISHED UNDER AUTHORITY OF THE SECRETARY OF THE AIR FORCE

Air Force OC, 17 Apr 72-1100

15 FEBRUARY 1962
CHANGE 504 - 6 APRIL 1972

Figure 5-14. Technical order page supplement title page.

command is unable to achieve or maintain mission capabilities.

Formal safety supplements are issued when a potentially hazardous condition could result in injury to personnel or damage to property or equipment. Formal operational supplements are issued when a condition could reduce operational efficiency or jeopardize safety. Safety supplements have a border of red "SSs" around the edge of the title page. Operational supplements have a border of black "OSs" around the edge of the title page.

Exercises (088):

1. Match the method of keeping TOs current in column B with the statement in column A that is most appropriate for that method. Some methods may be used more than once.

Column A	*Column B*
____ 1. Only issued when time and circumstances do not permit issuing a standard change.	a. Change.
____ 2. A heavy black line in the outer margin is used to indicate that this method has been accomplished.	b. Technical order page
____ 3. Can be either issued as part of a basic TO or after issuance of basic TO.	c. Revision.
____ 4. Occurs only when directed by the Numerical Index and Requirement Table.	d. Appendixes.
____ 5. Occurs only when 20 percent of the original TO still intact.	e. Rescission.
____ 6. Method is either cumulative or noncumulative.	f. Supplement.
____ 7. Method of correcting TO deficiency.	g. Safety supplement.
____ 8. Method of overcoming work stoppages or operational defects.	h. Operational supplement.
____ 9. Pages are colored green to denote this method.	
____ 10. Inserted at the end of the basic technical order.	

2. Assume that information given in a TO, if followed, would constitute a hazard, what type of safety supplements would be used?

3. When conditions reduce operational effieicncy or jeopardize safety, what type of operational supplement is used?

089. Point out selected characteristics of the technical order improvement report.

Types of Technical Order Improvement Reports. If you discover an error in a TO, you are responsible for reporting it. Submit the change on an AFTO Form 22, Technical Order System Publication Improvement Report and Reply. There are three types of reports: Emergency TO reports, Urgent TO reports, and Routine TO reports.

Emergency TO reports. These report conditions that require immediate correction to the TO. Safety and the unit mission are involved. Failure to make the correction will result in fatal or serious injury to personnel, extensive damage or destruction of equipment or property, or inability to achieve or maintain operational posture. (MISSION ESSENTIAL). The activity responsible for the corrective action must respond within 48 hours either by issuing a TCTO or by disapproving or downgrading the report.

Urgent TO reports. Urgent TO reports recommend the correction of nonemergency TO deficiencies involving hazardous conditions. These conditions can result in personnel injury, equipment damage, or prevention of safe mission accomplishment. Urgent TO reports must be answered by the responsible activity within 30 calendar days (this includes printing and distribution time). The activity must reply within 20 days if the action cannot be completed within 30 days or if the report is disapproved or downgraded.

Routine TO reports. These reports recommend improvements to TOs to correct potential hazards. These hazards may result from prolonged use and may have a negative effect on operation or maintenance efficiency. They may also reduce the life or general service of the equipment. Routine TO reports, with a few exceptions, must be replied to within 60 calendar days by the responsible activity.

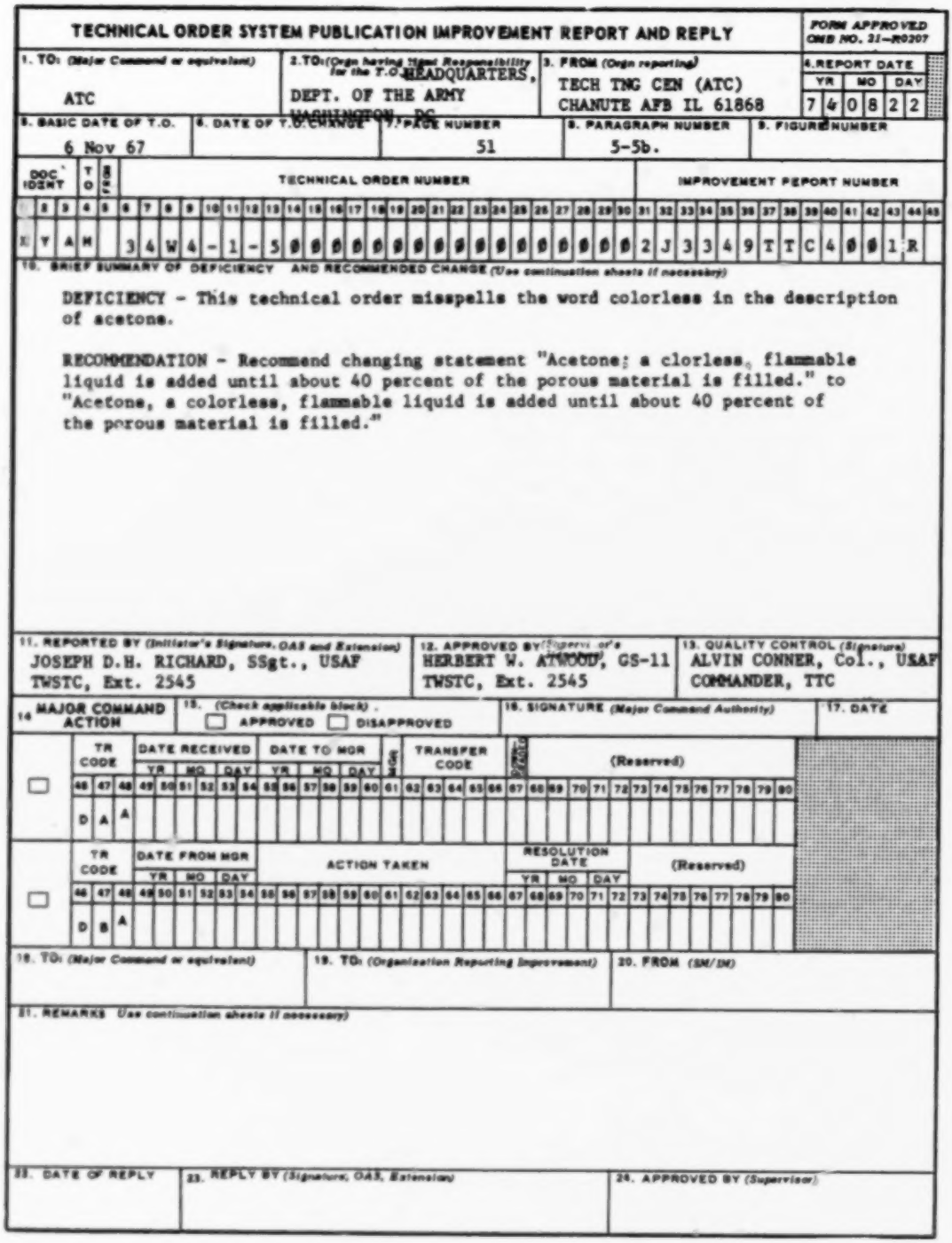
AFTO Form 22. The AFTO Form 22, Technical Order System Publication Improvement Report and Reply, is shown in figure 5-15. You, as the initiator, are responsible for completing blocks 1 through 11. To complete these blocks, consult TO 00-5-1, *AF Technical Order System.* Most blocks are self-explanatory, but the command designators must be obtained from the TO.

Exercises (089):

1. What responsive action must be accomplished when an emergency TO report is received?

2. What are Urgent reports used for?

3. Who initiates an AFTO Form 22?



TECHNICAL ORDER SYSTEM PUBLICATION IMPROVEMENT REPORT AND REPLY

FORM APPROVED OMB NO. 21-R0207

1. TO: (Major Command or equivalent)	2. TO: (Org having Mgmt Responsibility for the T.O.)	3. FROM (Org reporting)	4. REPORT DATE (YR MO DAY)
ATC	HEADQUARTERS, DEPT. OF THE ARMY WASHINGTON, DC	TECH TNG CEN (ATC) CHANUTE AFB IL 61868	74 08 22

5. BASIC DATE OF T.O.	6. DATE OF T.O. CHANGE	7. PAGE NUMBER	8. PARAGRAPH NUMBER	9. FIGURE NUMBER
6 Nov 67		51	5-5b.	

DOC IDENT	TO	SEC	TECHNICAL ORDER NUMBER	IMPROVEMENT REPORT NUMBER
XYAM			34W4-1-5	2J334 9TTC4 0018R

10. BRIEF SUMMARY OF DEFICIENCY AND RECOMMENDED CHANGE (Use continuation sheets if necessary)

DEFICIENCY - This technical order misspells the word colorless in the description of acetone.

RECOMMENDATION - Recommend changing statement "Acetone; a clorless, flammable liquid is added until about 40 percent of the porous material is filled." to "Acetone, a colorless, flammable liquid is added until about 40 percent of the porous material is filled."

11. REPORTED BY (Initiator's Signature, OAS and Extension)	12. APPROVED BY (Supervisor's	13. QUALITY CONTROL (Signature)
JOSEPH D.H. RICHARD, SSgt., USAF TWSTC, Ext. 2545	HERBERT W. ATWOOD, GS-11 TWSTC, Ext. 2545	ALVIN CONNER, Col., USAF COMMANDER, TTC

14 MAJOR COMMAND ACTION	15. (Check applicable block) ☐ APPROVED ☐ DISAPPROVED	16. SIGNATURE (Major Command Authority)	17. DATE

	TR CODE	DATE RECEIVED (YR MO DAY)	DATE TO MGR (YR MO DAY)	Mgr	TRANSFER CODE	Priority	(Reserved)
☐	DAA						

	TR CODE	DATE FROM MGR (YR MO DAY)	ACTION TAKEN	RESOLUTION DATE (YR MO DAY)	(Reserved)
☐	DBA				

18. TO: (Major Command or equivalent)	19. TO: (Organization Reporting Improvement)	20. FROM (SM/IM)

21. REMARKS Use continuation sheets if necessary)

22. DATE OF REPLY	23. REPLY BY (Signature, OAS, Extension)	24. APPROVED BY (Supervisor)

Figure 5-15. AFTO Form 22.

4. What responsive action must be accomplished when an Urgent TO report is received?

5. What are routine TO reports used for?

CHAPTER 6

Airframe Repair Safety

SAFETY IS a full time job. It is something that will affect you 24 hours of every day you are on or off duty. A safe way of living and of working is very important to you and your fellow airmen, not only for the present time but for your security and well-being in the future as well. This is true because a crippling injury may alter any plans you might have for a happy future.

Is the age in which we live safety-conscious? You need only take a glance at a daily newspaper to answer this question fully. Many news items and headlines relate to some tragic incident that has crippled or taken the lives of many and often times of innocent people. Most tragic of all, most accidents could have been prevented. This is emphasized by the many safety manuals that are published by the Air Force and civilian organizations in an effort to make people aware of hazards that cause accidents.

You can see readily, then, that this chapter concerns *you*. It should be read thoroughly and understood completely. So important is this matter of safety that you should not limit yourself to the material contained in this package course, but to keep yourself up-to-date, you should read all of the safety literature that is brought to your attention or that you may encounter in your daily reading. A little extra work in learning the rules of safety will assist in insuring that you live a happier and a healthier life.

Although your job may not always be the most dangerous one in the world, it is at the place where you will be spending a great part of your time; and it will be during working hours that you help or hinder your organization according to the degree to which you observe the rules of safety. Let us consider, then, some common safety practices that you and all workers should observe. In this chapter, we shall discuss several aspects of safety, including good housekeeping, fire prevention, electrical hazards, and flight-line safety, as well as proper care of tools.

6-1. Introduction to Accident Prevention

Approximately 90 percent of all accidents are caused by the unsafe acts of people. It is therefore important for you to be on the alert and try to correct or control your behavior before something happens. Airframe repair personnel work with many types of equipment in all kinds of surroundings, and their equipment and surroundings are sometimes dangerous because of the nature of their work.

090. Cite aspects of the causes of accidents and methods employed to prevent accidents.

Accidents do not happen without cause. The identification and elimination of accident causes are essential to accident prevention.

Causes of Accidents. Preventable accidents may be traced to causes originating in the heredity and early environment of individuals. These beginnings may be displayed by unsafe personal characteristics which allow a person to perform an unsafe act, overlook or tolerate an unsafe condition which may result in an accident. Detecting and eliminating unsafe characteristics (such as inattentiveness, excitability, impatience, and stubbornness) are normally extremely difficult. On the other hand, eliminating unsafe acts and conditions is a relatively simple and effective means of accident prevention.

Unsafe acts and conditions are the immediate cause of any accident. Usually, unsafe acts and conditions can be anticipated, readily identified, and eliminated almost immediately upon discovery. This is what accident prevention is all about. If the basic causes can be identified and eliminated, the associated unsafe acts or conditions will be removed and the accident cannot happen. Therefore, the basic causes must be found when possible.

Prevention Methods. Various methods are used to remove or make people aware of unsafe acts or conditions which lead to accidents. Each day you'll come in contact with these methods in one form or another.

Engineering. Environment and equipment causes of accident, or unsafe conditions, can often be eliminated through the application of engineering principles. Equipment and facilities will be designed, constructed, and maintained in consideration of safe engineering principles. Mechanical revisions or modifications may have to be made to eliminate existing unsafe conditions; special devices may have to be developed to correct specific unsafe conditions and, in some cases, to prevent unsafe acts. In general, safety engineering involves controlling the work situation to minimize physical hazards. Design of machine guards, working platforms, personal protective equipment, and hand rails are examples of safety engineering at work.

Education and training. Just as safety engineering

is the most effective way of eliminating unsafe conditions, education and training are effective means for prevention of unsafe acts by individuals. Through adequate instructions, personnel gain useful knowledge and develop safe attitudes. Safety consciousness developed through education will be supplemented and broadened by training in specific practices and skills. Training gives each man a personal safety tool by developing in him habits of safe practice and operation.

Enforcement of safety standards. Usually accidents can be prevented through adequate safety engineering, education, and training. However, some people are a hazard to themselves and others because of their failure to comply with accepted safety standards. For these persons strict enforcement of safety practices is necessary. No organized accident prevention effort can be successful without effective enforcement, because accidents are frequently the direct result of violations of safety principles. This is particularly true of vehicle accidents, many of which are caused by unsafe acts constituting traffic law violations.

Exercises (090):

1. What is the Accident Prevention Program all about?

2. What is the purpose of engineering safety?

3. Why is enforcement of safety standards required?

4. How is safety consciousness developed?

5. What are the immediate causes of accidents?

6. What factor of accident prevention is difficult to detect and eliminate?

7. What factor directly influence the performance of individuals in regards to safety?

091. Identify the source of guidance for shop and flight-line safety and cite the general safety practices you must observe to protect yourself from injury.

AFR 127-101. Your textbook for shop and flight-line safety is the *Accident Prevention Handbook,* AFR 127-101. It provides practical accident prevention information and guidance to all Air Force personnel. However, AFR 127-101 cannot cover all situations. Therefore, your ability to recognize and cope with hazardous conditions or faulty equipment may save your life. Work safely at all times.

The major point stressed in this regulation is that each airman is responsible for safety. The clothing you wear, the tools and equipment you use, your compliance with safety rules, and your personal habits toward safety are all items that you can control. How you control them will determine how safely you work.

General Safety Practices. There are a few safety practices that you must observe each day to protect yourself during the course of work. The little time it takes to comply with these safety practices will pay off in the long run.

Smoking. Smoking is not allowed within 50 feet of a hangar, fuel tank, parked aircraft, or area where flammable materials are stored. It is important to obey these smoking regulations to prevent the action shown in figure 6-1.

Horseplay. Horseplay is strictly forbidden, particularly around aircraft and during maintenance operations in the shop. Not only is "fooling around" dangerous to personnel, but it can result and *has* resulted in extensive damage to aircraft and in serious personal injuries.

Clothing. Clothing is an important factor to consider when stressing safety. Wearing the proper clothing can often make the difference between a safe working condition and a dangerous one. Loose clothing around machinery is dangerous. Loose clothing can get caught in the moving parts of the machine, dragging you into the machine. Take a minute and check your clothing before starting in an operation that involves powered equipment.

Clothing that has oil or solvent splashed on it is also hazardous. A spark could ignite the flammable substance and cause serious burns. The Air Force provides special clothing for dangerous jobs or jobs that must be performed in hazardous areas. It may save you from injury. No matter how silly you think some of the safety equipment looks, wear it.

Jewelry. Wearing jewelry when performing any type of maintenance action is a dangerous practice. Metal conducts electricity and heat very rapidly when an electrical current is forced through it. Even a momentary contact with an electrical conductor can heat a ring or watch to the point of causing a severe burn. You wouldn't intentionally place a hot branding iron against your wrist, so why take chances with a watch or ring? Take them off before you begin working.

A second reason for removing jewelry is the possibility of catching a watch or ring on a sharp corner or protruding bolt. People have had their fingers ripped completely off as a result of snagging a ring on some-

Figure 6-1. NO SMOKING.

thing while jumping off equipment. Protect yourself by removing jewelry before starting any job. The habits you develop on the job are important in accident prevention.

Exercises (091):

1. What kind of information is found in AFR 127-101?

2. State the safety rules concerning smoking.

3. Why is it required to remove all rings before accomplishing maintenance?

4. Cite two situations wherein your clothing could lead to an accident.

5. Why is horseplay strictly forbidden?

5-2. Shop Safety

Good housekeeping plays an important role in the prevention of accidents in an airframe repair shop. Good housekeeping is everyone's job. It is the job of the supervisor, technician, specialist, and apprentice to keep the shop clean and safe. To keep a shop clean, a basic rule to follow is: "If you don't do it at home don't do it here."

092. Indicate some of the housekeeping rules to follow in an airframe repair shop.

The quality of cleanliness and orderliness reflects the overall efficiency of the shop's operation. In addition to causing many injuries and health hazards, poor housekeeping also contributes to fires. Good housekeeping will be given due consideration in planning

all activities. Here are some good housekeeping practices to follow in reducing the causes of accidents.

Shop Floors. Shop floors must be kept clean and free of oil, grease, water, or other hazardous and slippery materials. Metal shavings, metal scraps, or other objects that could cause personnel to slip or stumble must not be allowed to collect on the floor. After you have completed a job, clean your area.

Waste Materials. Oily rags, waste, and other materials saturated with flammable substances should be disposed of in metal containers equipped with self-closing lids. These cans must be clearly marked for the disposal of waste only.

In the case of scrap metal, separate containers for each type of metal is required. The scrap metal should be cut small enough so as not to protrude out of the container where someone walking near could be cut.

Shop Tool Storage. Each piece of shop equipment must have a proper storage area. After using a tool or piece of equipment, return it to the proper storage area. This not only reduces the possibility of an accident. but insures that the next person to use the tool or equipment will be able to locate it.

Metal Storage. Each kind of metal must be stored separately and identified. This prevents the use of the wrong type and prevents galvanic corrosion. Galvanic corrosion is the result of electrolysis between dissimilar metals.

Metals should be stored in a rack and easily accessible. The metal storage rack keeps the metal off the floor, preventing a safety hazard. At no time should small pieces of m[illegible]l be cut off from metal still in the storage rack. If you need a piece, remove the metal from the rack, cut off what you need, and return the metal to the rack. It might take a little longer, but it might save your finger the next time you go to get a piece of metal from the storage rack.

Chemical Storage. The precautions to be used when storing chemicals cannot be overemphasized. The improper storage can result in fire, explosion, serious injury to personnel, and damage to equipment. Some basic rules to follow for safe chemical storage are:

a. Storage area should be a cool and dry place.

b. Provide ventilation to prevent fume buildup.

c. Identify acid and alkaline properly and store them separately.

If you are going to store chemicals, you are going to handle them. You should, therefore, know the rules for handling chemicals. They are:

a. Make certain you know what the chemical is before you handle it.

b. Do not smoke while handling chemicals.

c. Clean up spilled chemicals immediately.

d. Wash off any acid immediately with an abundance of water if you spill it on yourself. Apply bicarbonate of soda to neutralize any remaining spill.

e. Provide adequate ventilation.

Exercises (092):

1. What safety rule must be followed to prevent personnel from slipping in airframe repair shop?

2. What safety rule must be practiced concerning oily rags?

3. To avoid injuries, what safety practice is employed when placing scrap metal in waste containers?

4. To prevent injuries when removing metal sheets from storage racks, what work procedure should not be used?

5. What three safety procedures must be observed when storing chemicals used in an airframe repair shop?

093. Indicate the causes of most fires that occur in Air Force shops, list the three classes of fires, and identify the type of fire extinguisher to use for different classes of fires.

Fire Prevention. Closely allied with good housekeeping is a smooth working fire prevention system. This is necessary because the best cure for any fire is to prevent its occurrence. You will be required to carry out all safety precautions regarding the prevention of fires. You must also know what to do and how to do it when a fire does occur.

Many fires are caused by carelessness and by poor housekeeping. Oily rags that have been thrown in a corner are excellent material for a healthy fire. Poor storage practices of flammable materials have caused many fires. Overloaded electrical outlets coupled with defective circuit breakers may also cause a fire. NO SMOKING signs were made to be observed; lighted cigarettes or matches thrown in waste paper baskets full of paper are not usually put out by the fall. Here are a few precautions that you should observe with regard to fire prevention:

- Do not allow oily rags to accumulate.
- Observe the signs in the NO SMOKING areas.
- Never allow your clothing to become saturated with fuel or oil. If it should become that way accidentally, change your clothing as soon as possible.

- Do not permit gasoline, kerosene, jet fuel, or any other flammable fluids to be stored in open containers.
- Never deposit cigarettes or matches in a waste-basket, even when they appear to be extinguished.

You must be ready to fight all types of fires quickly and effectively, because fires will occur even when adequate precautions are taken. Referring to figures 6-2 and 6-3, you can see there are three classes of fires and five types of fire extinguishers commonly in use. The three classes of fires, as depicted in figure 6-2, are class A, class B, and class C. The five types of extinguishers, as depicted in figure 6-3, are (1) the pump tank, (2) soda acid, (3) foam type, (4) carbon dioxide, and (5) the chlorobromomethane type.

Most fire extinguishers look alike, but a fire may be made worse if the wrong type of extinguisher is used. Study figure 6-3 carefully; it tells you what kind of extinguisher to use for a particular type of fire, how to use it, the effective range, the principle by which it puts out a fire, and safety precautions to observe. Above all, determine the location and type of fire extinguishers in your work area and plan *how* they operate, *how* you would use them if the occasion should arise, and the types of fires they are suited for. However, your actions should be followed up by people trained in this area. This means that you should know the telephone number of the base fire department, the location of the fire extinguishers, and which type of extinguisher to use for the type of fire you are fighting. The telephone number for the base fire department is usually posted in large numerals. These posters are placed at intervals in the shop, in the barracks, and on the flight line. As a rule, the base telephone directory has this number printed in large numerals on the cover page or on one of the first pages of the book. Learn where the alarm boxes are installed on your base and how to use them.

Exercises (093):

1. What are the major causes of fires in Air Force shops?

2. List the three classes of fires.

Use figures 6-2 and 6-3 to answer the following question:

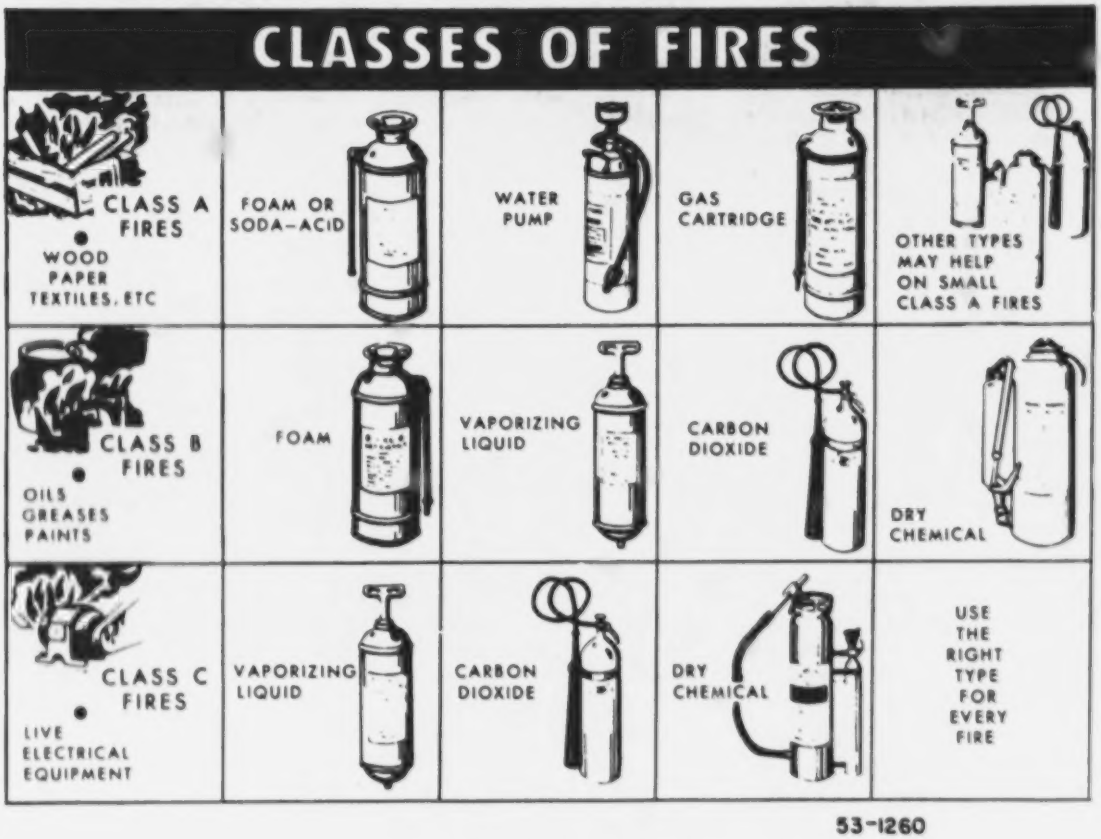


Figure 6-2. Classes of fires.

Type of Extinguisher	Pump-Tank	Soda Acid	Foam Types	Carbon Dioxide	Chloro-bromomethane
Use on:	Type A Fires: Wood, trash, paper, waste.	Type A Fires: Wood, trash, paper, waste.	Type B Fires: Gasoline, oil and oil base material, varnishes, etc.	Type C Fires: Electrical fires, confined fires on oil, ordinary combustibles.	Type C Fires: Electrical fires.
May also be used on:	--------	--------	Wood, trash, paper, waste.	Type A and B fires.	Small fires.
Method of using:	Direct stream at base of flames.	Work close for penetration. Direct stream at base of flames.	Apply complete blanket of foam over surface. Avoid a direct stream on oil surfaces.	Apply so that gas floods material in a wave-working with draft. Extinguisher lasts only a few seconds.	Direct stream on base of fire or hot surface.
Effective range:	--------	30 to 40 feet	30 to 40 feet	3 to 6 feet	15 to 30 feet
Principle of extinguishment:	--------	Cools burning surfaces below ignition point. Any stream generated tends to smother flames. Practically no gas leaves nozzle.	Blankets burning material with froth or foam, which excludes oxygen. Cools and insulates surface from heat. Blanket prevents flashbacks.	Flame is smothered by heavy blanket of nonflammable gas.	Upon contact with flame or hot surface, the liquid converts into a heavy smothering vapor.
Warning:	Never use on charged electrical equipment, varnish, oils or other fuels. Protect from freezing.	Never use on charged electrical equipment, varnish, oils or other fuels. Protect from freezing.	Never use on charged electrical equipment. Protect from freezing.	CO_2 will not support life. Avoid extended exposure in area where it has been used, especially in pits.	Do not use in closed areas. If liquid comes into contact with skin or eyes, wash immediately with water followed by medical treatment.

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Figure 6-3. Types of fire extinguishers and their use.

3. Match the classes of fires in column B with the type of fire extinguishers in column A.

Column A	*Column B*
_____ 1. Dry chemical.	Class A
_____ 2. Gas cartridge.	Class B
_____ 3. Vaporizing	Class C
_____ 4. Water pump.	
_____ 5. Soda acid.	
_____ 6. Carbon dioxide.	
_____ 7. Foam.	

4. The effective range of a carbon dioxide extinguisher is _____ to _____ feet.

094. Point out significant safety practices with the shop area associated with equipment operations.

Shop Equipment Safety. The equipment you work with must be as safe as possible. AFR 127-101 plays a key role in shop equipment safety. It governs the color coding of machinery parts, the grounding of electrical equipment, the guarding of moving machinery parts, and the safety inspections of your equipment. We will briefly examine these four areas of shop equipment safety.

Color coding of machinery parts. In the Air Force, the color coding of machinery parts identifies moving parts and stable parts. Usually stable parts are painted gray and the moving parts a bright color so that they can be easily distinguished.

Grounding of electrical equipment. Electrical equipment, whether stationary or portable, must be grounded to prevent electrical shock. If you have any doubt about its being grounded, don't use it until you can check it out.

Guarding of moving machinery parts. Guarding the moving parts of a piece of machinery protects the user from serious injury. If gears or saw blades are exposed, you're asking for trouble. Be sure that these parts are guarded and that personnel *do not* remove the guards for easier operation. This rule must be strictly enforced.

Safety inspection. The safety inspection includes the areas we have just discussed, and more. As a supervisor or subordinate, always be sure that your

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equipment is safe to operate. Know how to operate your equipment correctly and insure safety for yourself and others. It is the supervisor's responsibility to insure compliance with AFR 127-101 in the use of all shop equipment. If you are not yet a supervisor, this does not relieve you of this responsibility, because safety is *everyone's* responsibility.

Exercises (094):

1. List four shop safety areas governed by AFR 127-101.

2. If a machine part is painted orange, is it stable or movable?

3. When is it proper to remove the guards from a machine?

4. If you aren't sure that your electrical equipment is grounded, what should you do?

5. What factor will greatly reduce the chances of accidents when operating equipment?

095. Cite the safety precautions and practices to observe in the use of handtools and portable power tools.

The improper use of tools causes many accidents because the average person thinks that these are simple devices. They are simple devices, but they can be very dangerous if not used properly, as illustrated in figure 6-4. You should always give careful consideration to safety before using any tool. A little forethought may save many dollars in time lost and materials wasted as well as painful injury to you and others.

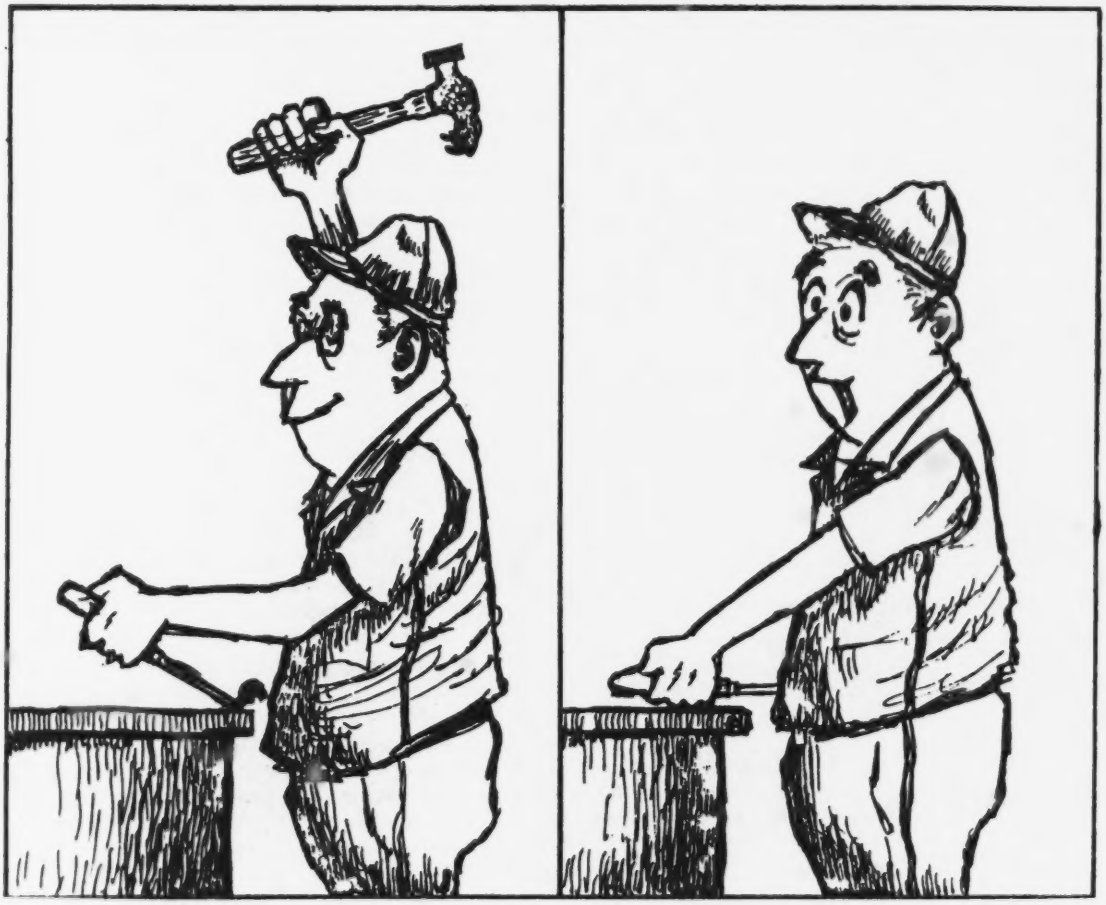

Figure 6-4. Unsafe acts.

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Handtools. Unsafe handtools have been blamed for many accidents and injuries, but the man who uses the tools is really at fault. Accidents can be avoided by using tools that are designed for a specific job (using the right tool for the right job) and kept in proper working condition. Some of the following tools if used improperly can cause you many hours of pain.

Hammers. The hammer is the most commonly used handtool and is involved in about 1 out of every 5 handtool injuries. You use the ball-peen, tinner's, and cellulose type hammers frequently. When doing any type of work with the hammer, always use the proper hammer for the job at hand. The ends of hammer handles should never be used for pounding or tapping, because this practice damages and weakens the handle. When striking an object with a hammer, make certain the hammer face is parallel to the face of the object being struck. Use soft, nonferrous hammers for striking casehardened or tempered tools and surfaces; never use hammers that show defects, such as cracks in the face or head. Flying particles can injure your eyes.

Screwdrivers. Screwdrivers present an accident hazard because many people don't know how to use them properly. The screwdriver is designed for one principle purpose—to loosen and tighten screws. When it is used for other purposes—which it often is—it may cause a variety of accidents. Always use a screwdriver of the proper size for the job. Make certain that the size of the blade matches the screw slot. Do not hold work in one hand and the screwdriver in the other. Use a vise or a suitable rest to secure the work. Never use a screwdriver as a substitute for a nail puller, punch, or chisel, because these practices will bend the shank, mar the blade, or splinter the handle.

Files. All files present hazards because of their brittleness, abrasive surfaces, and tanged handles; therefore, you should practice safety in the use of files at all times. A file without a handle should never be used, since the tang may be forced into your hand if an obstruction is met. Select a handle of the proper size for the tang and tap on securely before use. The part filed must be clamped in a vise or otherwise made secure, and its surface must be adequately protected against marring by some soft material between the material being worked and the vise jaws. A file must never be used for prying. The tang end is soft and bends easily. The body of the file is very brittle and will snap under strain or stress. Hammering on a file is dangerous because the file may splinter and scatter sharp fragments that are dangerous to you and others. They can put out an eye.

Punches and cold chisels. Punches, chisels, and other tools which must be held by hand and struck should be kept free of oil, grease, and other slippery substances. When striking these tools, hold them near the top to minimize the danger of striking the hand solidly. A rubber guard may be fitted on the punch or chisel above the hand to guard against striking your hand. Wear goggles or a face shield at all times when using a punch or chisel on metal or other brittle material to protect your eyes. The heads of striking tools should always be kept shaped. Mushroomed heads are very dangerous, since flying bits of metal may strike either you or someone nearby.

Portable Power Tools. The portable power tool is supplied with power from an external source which permits increased mobility. Portable power tools may be operated by electricity or air pressure, or by means of a rotating flexible shafting. Hazards connected with the use of portable power tools are electrical shock, burns, cuts, bruises, strains, particles in the eyes, and explosions.

Electrical tools. These tools are used in many operations. Because of the source of power, electrical hazards are present. Many of these, in addition to hazards associated with the tool itself, can be eliminated. Unless electric power tools are of an approved explosion-proof design, they should never be used in an area where flammable liquids or gases are present, used, or stored. You should always see that exposed metal parts are grounded properly. Grounding is very important when electrical power tools are used in wet or damp locations. Electrical cords on power tools must not be subjected to such abuses as scraping, contact with oil and grease, kinking, flexing, crushing, and excessive tension. Always inspect the cord before using it. If the cord is defective, get it replaced at once. Electric extension cords must be properly connected and secured to prevent a spark due to accidental disconnection. Use the overhand tie to more properly secure the connection of extension cords when in use. Remove these extension cords and store them where they will not be subjected to abuse.

Compressed air operated tools. Compressed air operated tools are safe to use around aircraft and where there is a possibility of fire hazards due to flammable liquids and gases. Use good-quality hose and be certain that all hose connections are secure. The air valve should always be operated and controlled by hand. If you are using pneumatic hammers, do not point them at anyone, since the rivet set may be thrown out and could cause injury to someone or something. If you must change rivet sets or other tools, always shut off the air or disconnect the hose from the hammer. Many people do not realize the dangers of horseplaying with compressed air. Do not use air for any other purpose than that for which it is intended. The practice of blowing dust or dirt off your clothing or the clothing of others must not be allowed.

Exercises (095):

1. To reduce the chances of injury in using hammers, what must you always remember?

2. What is the number one reason people get injured using screwdrivers?

3. List some safety practices to employ when using a file.

4. What safety devices should be used when using striking tools such as punches and cold chisels?

5. When are electical tools permitted in areas where flammable liquids or gases are present?

6. List three "don'ts" associated with compressed air operated tools.

096. Name the personal safety equipment to be worn in specified situation.

Personal Safety Equipment. Millions of dollars are spent on designing the safest possible equipment, safe working environments, and safety training each year. But all this is wasted if you don't use the personal safety equipment required to protect yourself from injury. The most valuable asset the Air Force has is not airplanes or missiles, but YOU. Without you, there would be no Air Force. This is why the use of personal safety equipment is continually stressed.

A variety of personal safety equipment has been developed for your use in different work situations. The following ones are the most often required in an airframe repair shop.

Goggles. Almost all eye injuries can be prevented by the use of suitable safety goggles. Eye protection is required where there is a reasonable probability of injury that can be prevented by such equipment. Suitable eye protection will be worn where machines or operations present the hazard of flying objects.

Face shields. Face shields give protection to the eyes and face from small flying particles. They are usually used in place of goggles where increased vision is necessary or where goggles are subject to excessive fogging, as well as in operations where the entire face needs protection. On most face shields, a transparent visor of nonflammable material is attached to a headband in a manner that it can be pushed up and back out of the way when necessary. Face shields are available in various sizes, strengths, and light-filtering capacities.

Respirators. Many of the activities in an airframe repair shop produce atmospheric contaminants that are harmful, in varying degrees, to the health of the person performing the work. The contaminants may be in the form of dusts, gases, vapors, fumes, and mist. Operations, such as sanding fiberglass, mixing resins, cleaning work surfaces, and applying corrosion preventatives, produce these contaminants. A respirator, such as the series R6000 type, will be worn when you perform any operation producing contaminants.

Safety toe shoes. Safety toe shoes should be worn by personnel working in areas where heavy materials are handled, such as sheets of metal, and while performing operations considered hazardous to your feet or toes. Operation of foot shears and like equipment in the airframe repair shop requires foot protection. Regular safety shoes are considered part of the job wardrobe.

Gloves. Thick leather gloves should be used when handling large sheets of metal. Handling such metal as stainless steel without gloves is a sure way of cutting yourself. Also, the protection of your hands is required when working with resins and sealants related to fiberglass repairs.

Ear protectors. As an airframe repairman, you work in a noise hazard area. Noise levels of 100 to 120 db and above are common in the daily operation of an airframe shop. Noise levels of 85 db and below are considered relatively safe. So you see the reason for ear protection while in the shop area. Ear plugs or ear muffs or a combination of both should be worn when you are exposed to noise hazards.

Exercises (096):

1. When is eye protection required?

2. If you were assigned to move sheets of metal, what safety equipment would you use?

3. Activities producing atmospheric contaminants require what safety device be worn by the individual accomplishing the activities?

4. Why is ear protection required in an airframe repair shop?

5. In operating a nonpowered squaring shear, the operator should be wearing what type of personal safety item?

5-3. Flight-Line Safety Practices

The flight line can be a very dangerous place for someone who isn't familiar with its hazards. You must continually be alert for situations that could lead to injuries to yourself and others. If you observe them, the safety practices and procedures discussed in this section can reduce the hazards of working on the flight line.

097. Given specific flight-line situations, give the precautions to be taken in each.

Certain hazards exist on the flight line over which you have little or no control. Your work will take you into these hazardous areas and you must use the proper techniques to protect yourself. We can best describe these hazards by categorizing them as aircraft hazards, noise hazards and radiation hazards.

Aircraft Hazards. Aircraft are dangerous for personnel working on the flight line. When aircraft engines are running, there is the suction of the intake and the thrust of the exhaust. The air inlet is considered to be more hazardous because of its ability to draw in foreign objects. The intent of figure 6-5 is to point out that not only small items, such as screws and bolts, are drawn into the engine, but even people have been picked up and drawn into the engine.

The thrust of the exhaust can turn objects into missiles, which can severely injure personnel and damage equipment. Because of these dangers, you must observe the safety zones for both intake and exhaust. These zones vary with different aircraft, but not normally considered to be 25 feet away for the intake and 200 feet away for the exhaust.

There is also the danger of aircraft accidents. When an aircraft moves on the flight line, it has the right-of-way, and all other vehicles must yield. If you drive on the flight line, you must remember this. Also, if you must cross a runway or taxiway, you must always check the control tower. A green light will appear if you can cross, as with ordinary traffic signals.

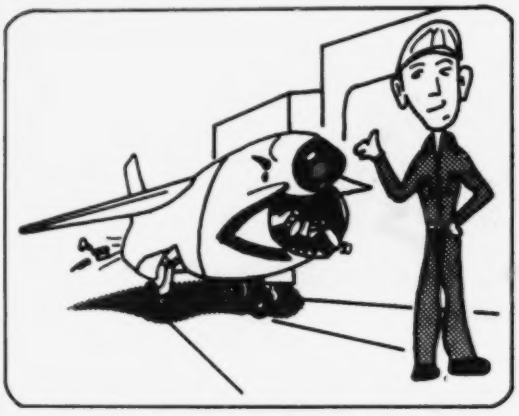

Figure 6-5. Intake precautions.

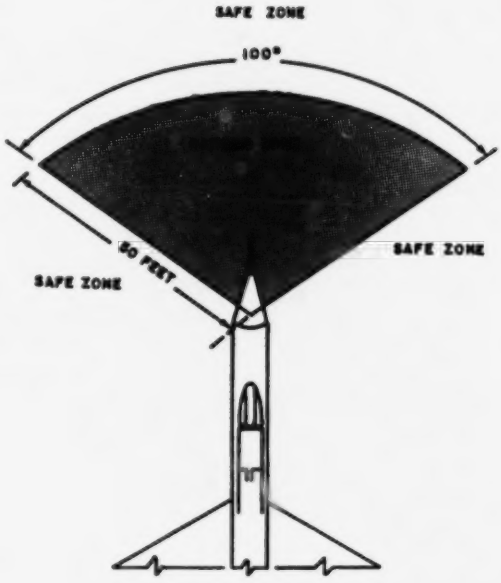

Figure 6-6. Radar danger areas.

Noise Hazards. Any aircraft has powerful engines that create a noise hazard. The loudness and pitch of the noise can cause severe damage to the human ear. Always protect your ears when you are working around operating engines. Also, observe the safety zone for the aircraft exhaust. The noise safety zone is approximately 300 to 400 feet at the rear of the aircraft, depending on the type of aircraft.

Aircraft engines are not the only noise hazards on the flight line. A noise hazard could be the shrill sound of a siren, the whine of pneumatic tools, or the roar of aerospace ground equipment (AGE). Whatever the noise hazard is, the precaution is the same: wear appropriate ear protection (ear plugs or muff type ear protectors or both).

Radiation Hazards. This hazard is one you can't see or hear. Your exposure to radiation on the flight line comes from two areas—aircraft radar and X-ray equipment used by nondestructive inspection personnel.

Aircraft radar is extremely dangerous because of the intensity of the radiation it produces. This radiation, when of sufficient intensity, can damage human tissue, particularly the eyes. This type radiation is also dangerous near fueling operations, explosives, ammunition, and other flammable materials. During periods of ground transmission, your best protection is distance. Figure 6-6 indicates the danger zone for aircraft radar.

Warning signs must be displayed and obeyed during radar operational check. When an area is roped off for an operational check, keep out of that area unless you have specific permission to enter.

The X-ray equipment used by NDI personnel produces X-radiation. Harmful effects of unshielded exposure to X-radiation increases with increased voltages. In X-raying an aircraft part, the voltage required to produce an acceptable film produces a high level of X-radiation. The amount of harmful effects this X-radiation will have on you depends on how long you were exposured to it. Your best protection is to obey the warning signs and remain out of the area. Figure 6-7 shows a radiation warning placard. All radiation signs display the distinctive magenta insignia against a yellow background with black block type. The warning signs are designed to attract immediate attention.

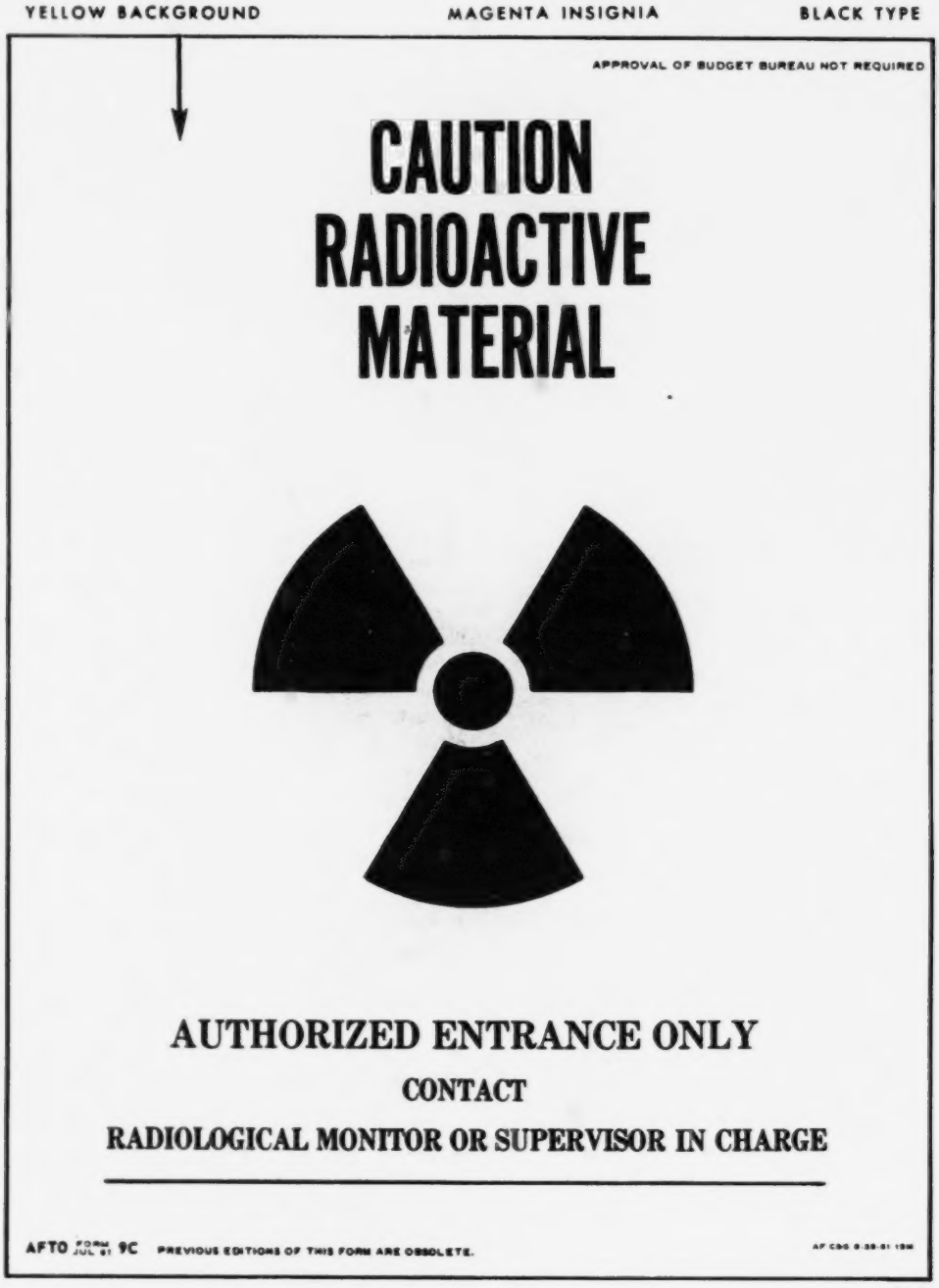

Figure 6-7. AFTO Form 9c.

The French Spad S.13-C.1 was perched on an airstrip near Grand Pre that March day in 1918. The soon-to-be-famous American "Hat-in-the-Ring" squadron insignia was painted in brilliant red, white, and blue on its tapered fuselage. Also painted on the plane were the instructions, "Non Marche" and "Marche Ici".

After a brief briefing on the day's patrol, the American pilot, Wick N. Basket, equipped only with one semester of high school French under his aviator cap, bolted to his bird . . . and proceeded to poke his foot through a "No Step" instruction decal.

Figure 6-8. Aircraft walkway signs.

Exercises (097):

1. You are driving a vehicle and must cross the runway. The tower shows a red light. What do you do?

2. You have been working on a blast deflector 100 feet behind an aircraft, and the aircraft is going to start. What must you do?

3. You are well outside the danger zone of an aircraft that is about to start. What should you do?

4. You are working on the nose section of an aircraft and the crew chief starts a ground power unit. What precaution should you take?

5. If the radar system on an aircraft you are repairing is being operated, what precaution should you take?

098. Cite the safety actions to observe or perform when accomplsihing flight-line maintenance.

Maintenance on the flight line requires additional safety practices along with those practiced while working in the shop. When performing flight-line maintenance the following precautions should be followed.

Maintenance Stands. When access to the aircraft is not possible from ground level, a suitable maintenance stand is used. You should insure that the stand is free of oil, grease, or any other substance which could cause injuries through slips and falls; also, that the wheel locks work and that the guard rails are in place where work locations and aircraft configuration permit. Guard rails must not be used for ladders or work platforms. If you raise the work platform, the locking pins must be installed.

Aircraft Walkway. The aerodynamic efficiency of aircraft can be materially affected by damage resulting from maintenance personnel walking on aircraft surfaces. The story and illustration in figure 6-8 give a glaring example of what could happen. When repair work makes it necessary to work or step on the aircraft, use the designated walkways. Under no circumstances should you step on air scoops, exhaust stacks, control surfaces, etc., which are not designed for such purposes. Safety cables and safety body belts are required when you are working on the larger aircraft, such as the C-5 aircraft.

Cockpit Safety. If you have no business in the cockpit area, stay out of it. Special precautions should be taken if you are required to work in the cockpit. First, make sure that all safety pins are installed. If you've forgotten—or just don't know—the location of the pins, have someone who does know check first before you enter. Secondly, after you're in the cockpit, leave switches, levers, and buttons alone. Playing with switches, levers, or control stick could end in a disaster.

Special caution should be taken with the egress system (crew escape system). This system contains explosive charges which blow the canopy and seat from the aircraft. If maintenance is to be accomplished on or near this system, call an egress specialist. Don't be like the repairman in figure 6-9.

Movable Surfaces. Most aircraft flight control surfaces are positioned by hydraulic or electric power. Because of this, the man in the cockpit operating these surfaces is unaware that their movement has met an obstruction. That obstruction could be your hand, arm, head, or body.

Most surfaces move slow enough for you to move out of the way; exceptions to this are bomb-bay doors, spoilers, speed brakes, and landing gear doors. These move so rapidly you have no time to react. They are as deadly as a guillotine.

To prevent injury, safety locks should be installed while you work on movable surfaces. Also, a placard reading, "Maintenance in progress, do not operate

Figure 6-9. Do not play with switches or levers.

(indicate system), check aircraft forms," should be placed in the area where the controls of the system are located.

Exercises (098):

1. Before using a maintenance stand, what items should you inspect for?

2. What is the best safety rule to practice concerning aircraft cockpits?

3. If you are repairing the trailing edge of an aileron, what precautions should you take to protect yourself?

4. What action should you take if you're not sure of the location of safety pins in the cockpit area?

5. Why are designated walkways outlined on aircraft surfaces?

099. State the purpose, classifications, and preventive practices associated with the foreign object damage (FOD) program.

Because of the vast amount of money and time spent on repairing and replacing jet engines and aircraft components with foreign object damage, enough emphasis *cannot* be placed on its prevention.

Purpose of the FOD Program. Foreign object damage (FOD) is damage to a jet engine caused by a solid object being drawn into the intake and ingested by the engine. Another type of foreign object damage results when an object is left in aircraft, causing damage or the malfunction of the component.

The purpose of FOD programs is to reduce the amount of FOD by calling to the attention of maintenance personnel the important need for reducing the causes. Also, to outline preventive procedures to employ.

The responsibility of preventing foreign object damage does not rest with the commander or Chief of Maintenance alone. It is the responsibility of all maintenance personnel assigned, and each individual will utilize all means available to eliminate foreign objects from operating areas.

Classification of FOD Objects. Because of the large variety of objects that will cause damage to jet engines and aircraft components, it is necessary to group the objects into classes. There are three basic classes: stone, metal, and miscellaneous.

Stones. Stones are the *primary* cause of foreign object damage in jet intakes. This class is broken down into two groups, or types: the natural (such as rocks, sand, and gravel) and unnatural (such as cinders, asphalt, and concrete).

Metal. This class is broken down into three groups:

a. Aircraft and engine fasteners, such as nuts, rivets, screws, and lockwire.

b. Mechanic's tools, such as pliers and wrenches.

c. Flight-line metals, such as nails, badges, mechanical pencils, keys, and coins.

Miscellaneous. This class includes items not contained in the first two classes. Some examples of the miscellaneous class are wood, ice, clothing, and organic matter, such as birds and humans.

Preventive Methods. There are many methods of preventing FOD. The best way is to eliminate all foreign objects from the area. Here are some of the ways that have proven successful in reducing FOD damage.

Walk down. One way is to police the aircraft parking area as part of the daily routine. This should be conducted at the beginning of each day and prior to launch and recovery times.

Clothing. The second method is to insure that personnel working in and around jet aircraft and engines not wear loose clothing which may be drawn into the engine. Articles such as rags, hats, and gloves are easily drawn into jet engines.

Tool inventory. All maintenance personnel are required to inventory their tool boxes both BEFORE and AFTER performing a maintenance task. These two inventories can then be compared to determine if any tools are missing. This method of inventory is used to reduce the possibility of tools being left in engines, engine bays, wheel wells, bomb bays, and airframe structures.

Don't be foolish like the individual depicted in figure 6-10. The large number of tools in an airframe repairman's tool kit lends itself very easily to having one overlooked. If you want to avoid the situation shown in figure 6-11, keep track of your tools at all times.

Repair parts inventory. This type of inventory accounts for every nut, bolt, washer, rivet, and piece of safety wire used during the performance of maintenance.

Removal of personal items. This method is the most important and often overlooked. Maintenance personnel must insure that all loose objects are removed from their pockets while in the vicinity of operating aircraft and engines.

Exercises (099):

1. Why is there a FOD program?

2. State the classifications of FOD objects.

Figure 6-10. Tool box inventory.

Figure 6-11. FOD results.

3. State the methods used to prevent FOD.

4. Who has the responsibility for preventing FOD?

5. What is the prime cause of engine FOD?

6. Which method of FOD prevention is the most important and often overlooked?

100. Define the term "ground accident," and state aspects of the types and actions resulting when a ground accident occurs.

Ground accidents are mishaps that occur on ground or water, on or off an Air Force installation, involving Air Force military or civilian personnel or Air Force property. Mishaps that are classified as aircraft, explosives, missile, or nuclear accidents will not be reported as ground accidents.

Reportable Ground Accidents. Any injury that causes temporary total disability to Air Force military or civilian personnel or other personnel as a result of an Air Force ground operation is a reportable ground

accident. Reportable accidents also include mishaps that cause damage to Air Force property or damage to non-Air Force property as the result of an Air Force ground operation. Mishaps causing an injury that does not result in the total disability of the individual to perform his duty even for a short period are called nondisabling injuries and are reported locally according to major command procedures. They *are not* reportable ground accidents.

Major ground accident. Classify any ground accident as major if reportable injuries result in one or more fatalities or five or more disabling injuries from the same accident. Ground accidents are also considered major if reportable property damage is $10,000 or more.

Minor ground accident. Reportable ground accidents that do not meet major ground accident criteria are classified as minor ground accidents.

Accident Reporting. The two main reasons for reporting USAF accidents and incidents are to rapidly notify proper authority that a mishap of stated proportion and impact has occurred and to report the results of the mishap investigation. As early as possible after an accident has happened, the Air Force needs to know what property was damaged, what the cuases were, and how many people were injured or killed. The Air Force must do what is necessary to prevent further damage or injury and take corrective action to prevent recurrence. The activities with technical control of property (the ones that develop it or test it) and those with operational control (the ones that own it or use it) must take part in investigating the damage. Each of these activities must be notified of the accident.

The investigating commander will appoint an investigating officer or investigating board. The investigating officer for ground accidents may be a ground safety officer, maintenance officer, or rated officer, as appropriate. He may be a noncommissioned officer (NCO), provided the NCO is senior to the person involved, and is from a unit not involved in the accident, or is from the next higher supervisory echelon of the unit that had the accident.

Major ground accident. All major ground accidents will be reported by message, within 8 hours, to the following places as minimum requirements:

- Chief of Staff of the Air Force (CSAF), Washington, DC
- Air Force Inspection and Safety Center, Norton AFB, CA.
- Major command concerned.
- Air Force Systems Command (AFSC) IG, Andrews AFB MD.
- Air Force Logistics Command (AFLC) IG, Wright-Patterson AFB OH.

A complete formal report will be submitted on AF Form 711, *USAF Mishap Report,* with AF Forms 711a through h attached as applicable. Major ground accidents are reported by the installation ground safety officer acting for the investigating commander.

Minor ground accidents. Acting for the investigating commander, the installation ground safety office reviews the proceedings, findings, recommendations, and actions of the accident investigation. They evaluate the formal mishap report (AF Form 711 ab, Ground Accident Report—Non Major) and submit it to the major command concerned within 15 calendar days. A common policy is to appoint the second line supervisor of the person involved in minor ground accidents as investigating officer. In your case, this would be the Fabrication Branch Chief.

Worker Responsibility. If you observe an accident in your section, your primary responsibility is to aid the injured and evacuate the area if additional injury is likely. Notify your supervisor as soon as practical. Your supervisor should report the accident to the ground safety office or the squadron safety officer, who in turn would notify ground safety.

Local policy will be followed to determine the exact chain of command within the organization for accident reporting. For example, the squadron commander may have the policy that he will be the first to know. Remember, though, in the case of a major ground accident, the report will be submitted by message within 8 hours. For this reason, notification of the ground safety office will not be unduly delayed.

During the investigation of an accident, witnesses *are not* sworn and *do not* testify under oath. They are advised before they testify that the sole purpose of the investigation is to determine all factors relating to the mishap and in the interest of accident prevention, to preclude recurrence.

Exercises (100):

1. What is a ground accident?

2. What makes a ground accident reportable?

3. When is a reportable accident classified as a major ground accident?

4. Why are accidents reported?

5. Who reports ground accidents?

6. How soon after a major ground accident must the Air Force Inspector and Safety Center be notified?

7. What is your immediate responsibility if you witness an accident?

8. You break your leg playing football on Saturday. You show up for work Monday and are assigned as dispatch board monitor until the cast is off. How is the accident reported?

9. An airframe repair specialist is killed in a privately owned auto when it collides with a train. How is the accident reported?

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Answers For Exercises

CHAPTER 1

Reference:

001 - 1. 1. e.
2. d.
3. b.
4. a.
5. c.

002 - 1. 531.
002 - 2. Indicates individual specialty in which you work.
002 - 3. The fourth.

003 - 1. 53010
003 - 2. 1. 53010—Metalworking Helper.
2. 53133—Apprentice Airframe Repair Specialist.
3. 53153—Airframe Repair Specialist.
4. 53173—Airframe Repair Technician.
5. 53195—Metalworking Superintendent.

004 - 1. Job descriptions for all airmen AFS at the different skill levels.
004 - 2. The STS sets the level of training you will receive at each skill level.
004 - 3. For planning purposes.
004 - 4. Used to identify the proficiency required at each skill level.

005 - 1. Drill, rivet, cut, form, and bond metal in the fabrication and repair of metal and nonmetal parts and components.
005 - 2. With supervision.
005 - 3. By assisting a skilled specialist.

006 - 1. Performance.
006 - 2. Repair, modify, and fabricate aircraft metal, plastic, fiberglass, and honeycomb structural parts.
006 - 3. The experience will be helpful as a technician.
006 - 4. Team leader of repair crews and conducting phases of on-the-job training.

007 - 1. 53173.
007 - 2. Shop or shift supervisor.
007 - 3. a. no, b. yes, c. no, d. yes, e. no.

008 - 1. 53195.
008 - 2. Master Sergeant.
008 - 3. Supervision.
008 - 4. B and d are circled.

009 - 1. Classified.
009 - 2. Unclassified.
009 - 3. Unclassified.
009 - 4. Of possible intelligence value.

010 - 1. Top Secret.
010 - 2. For Official Use Only.
010 - 3. Confidential.

011 - 1. Only authorized personnel who have a need for the material.
011 - 2. The locations where the prescribed facilities are available for its secure storage or protection.
011 - 3. Attendance at a conference, overhearing a conversation, or being exposed to classified material in the performance of your regularly assigned duties.
011 - 4. Money, drugs, and other valuables.
011 - 5. Security category and type of material.

012 - 1. c. and d.
012 - 2. d.
012 - 3. a.
012 - 4. b. and c.

013 - 1. The right and need to know.
013 - 2. Not unless he can clearly establish his need to know.
013 - 3. No.

CHAPTER 2

014 - 1. Leadership qualities.
014 - 2. Sincere, friendly, and patience.
014 - 3. Creates a willing, cooperative, progressive, and continuously improving work force.
014 - 4. Rate the individual on actual performance rather than upon his friendly overtures to you.
014 - 5. Each worker is an individual.

015 - 1. So that the worker will be happy and satisfied with his job.
015 - 2. Give any three of the following:
1. Give a man a pat on the back and a little praise when he does a good job.
2. Use letters of appreciation and commendations.
3. Recommend outstanding performance ratings.
4. Recommend personnel for promotion, upgrading, and better assignments.
5. Encourage use of suggestion programs.

015 - 3. Supervisor's attitude and conduct.
015 - 4. By being friendly, helpful, and fair in his dealing with the worker.

016 - 1. Mission completion and personnel safety.
016 - 2. Safety.
016 - 3. Request.
016 - 4. (1) Control work in another location.
(2) Give orders involving precise specifications or complicated details.
(3) Hold a worker strictly accountable.
(4) Control work in which the order of performance is important.

016 - 5. (1) Explain minor details.
(2) Give assistance.
(3) Clarify a written order.
(4) Give instruction in an emergency.
(5) Stimulate worker interest.

017 - 1. c.
017 - 2. a.
017 - 3. b.
017 - 4. d.
017 - 5. f.
017 - 6. e.

018 - 1. Coordinate with your supervisor about the higher priority work request; then coordinate with the other shop supervisor and your specialist about completing the higher priority work. Be prepared to delay the lower priority work.
018 - 2. To keep everything in balance within the shop and with outside activities. This is necessary for mission completion.

019 - 1. Size of workload, number of people, each one's skill level, and the equipment available.
019 - 2. Mission.
019 - 3. Repair of the aircraft part.

020 - 1. Flying requirements.
Scheduled maintenance.
Inspection results.
020 - 2. For improvement within his area.
020 - 3. In-shop records.

021 - 1. True.
021 - 2. False.
021 - 3. True.
021 - 4. False.
021 - 5. False.

022 - 1. Span of control.
022 - 2. Unity of command.
022 - 3. Logical assignment.
022 - 4. Delegation of authority.

023 - 1. Usually four, the level being charted, the one above, and the two below.
023 - 2. Blocks 4c should be on the same level and size as blocks 4a and 4b.

024 - 1. Skill level and experience, job priority, and work distribution.
024 - 2. Assign it to Ed to round out his experience and knowledge.

025 - 1. What constitutes a satisfactory job.
025 - 2. To tell him what is expected of him in completing his job.
025 - 3. Operating details are overemphasized.
025 - 4. Realistic; practical.
025 - 5. A certain range of performance is considered acceptable.
025 - 6. 1. Quantity of results in a given time.
2. Quantity of results in how well a job must be performed.
3. Manner of performance.

026 - 1. 1. How does the worker meet the performance standards?
2. What are his working conditions?
3. What is my attitude toward him?
026 - 2. Give any five of the following:
1. Improve production.
2. Improve worker attitude.
3. Provide a basis for estimating future work capacity.
4. Provide a basis for planning, organizing, and assigning work.
5. Provide a basis for planning training.
6. Provide a basis for formal evaluation.
7. Provide a basis for personnel actions.
026 - 3. 1. Did I supervise properly?
2. Are my personal feelings affecting my evaluation?

027 - 1. 1. To improve methods, by making them safer, cheaper, and faster.
027 - 2. (1) Suppest program, (2) chain of command, and (3) complaint program.
027 - 3. An adopted change that saves money.

028 - 1. Training needs is the difference between what a trainee can do and what he must do.
028 - 2. Valuable time and money would be wasted.
028 - 3. By checking the specialty description, the STS, and performance requirements.
028 - 4. Background, training, and experience.

029 - 1. OJT is the concern of everyone assigned to the unit.
029 - 2. AFM 50-23 is used for planning, administering, supervising and conducting OJT programs.
029 - 3. The career development channel provides the knowledge portion of the training, while the job proficiency channel provides the actual performance of the job.
029 - 4. The STS is used to assign required training and record completed training.

030 - 1. c.
030 - 2. a.
030 - 3. a.
030 - 4. b.
030 - 5. d.
030 - 6. c.
030 - 7. b.
030 - 8. d.

031 - 1. e.
031 - 2. a.
031 - 3. c.
031 - 4. a.
031 - 5. d.
031 - 6. e.
031 - 7. b.
031 - 8. f.
031 - 9. e.
031 - 10. c.
031 - 11. d.
031 - 12. a.
031 - 13. f.
031 - 14. e.
031 - 15. b.

032 - 1. AF Form 623a.
032 - 2. Section IV.
032 - 3. Section I.
032 - 4. Section II.
032 - 5. Section V.
032 - 6. Section III.
032 - 7. Section I.
032 - 8. Section IV.

033 - 1. To evaluate present training.
033 - 2. STS.
033 - 3. When the graduate does not meet the proficiency level; when the graduate is not required to perform tasks listed in the STS; and when STS code levels or tasks exceed the requirement of the graduate's AFSC.
033 - 4. CDCs are designed to provide the learning materials. OJT utilizes these knowledges to train the trainee.
033 - 5. By having discussions with the graduate, his immediate supervisor, and others having knowledge of the graduate's performance.
033 - 6. Questions pertain to the graduate's qualification in terms of skills and proficiency levels reflected in the approved training standard.
033 - 7. To identify, if any, weak areas in the CDC.

CHAPTER 3

034 - 1. To insure that the necessary supplies and equipment are available for the AF to meet its mission requirement.
034 - 2. Needed; justified.
034 - 3. AFM 67-1, *USAF Supply Manual.*
034 - 4. The cost of an item.
034 - 5. Priority.

035 - 1. 4730—Federal Supply Classification Code (Group and Class).
00-194-1089—National item identification Number. The first two digits, 00, represent the country assigning the stock number, and the remaining digits distinguish a specific item of supply.
035 - 2. To segregate items for management purposes, identify according to their application, and indicate items associated with special programs.
035 - 3. All participants using the Federal Cataloging System must agree.

036 - 1. 5340.
036 - 2. Water turbines and water wheels; and components.
036 - 3. C-RL-2.
036 - 4. C-RL-2.
036 - 5. C-RL-1.

037 - 1. To locate the specific group class numbers.
037 - 2. To complete the rremaining portion of the stock number.
037 - 3. To find the item description.
037 - 4. To cross-reference the part number to a stock number.
037 - 5. To find the unit of issue, source category, and cost.

038 - 1. 1. d.; 2. e., 3. c., 4. a., 5. b.
038 - 2. a. 4151, b. J, c. 0050, d. EB, e. 629.

039 - 1. 1. The telephone extension was not given.
2. Unit of issue should be EA, HD DZ BX, etc., not 01.
3. Quantity should be preceded by slashed zeros (Ø).
4. Nomenclature is entered in wrong block.
5. Destination is not given.

040 - 1. When you need to order a part that doesn't have a stock number.
040 - 2. 4266.
040 - 3. 122cw.
040 - 4. This is necessary to insure that the correct item is purchased.
040 - 5. In case questions arise concerning the purchase of the part or a possible substitute.

041 - 1. When checking out an item for a short period of time.
041 - 2. When ordering parts and signing for parts received.
041 - 3. Block 13, Julian date and time; block 14, signature; and block 15, printed name and rank.
041 - 4. They provide supply with records of issues and hold the receiver of the items accountable.

042 - 1. Becuase it can be used both for issue and turn-in of supplies.
042 - 2. Request for replacement of condemned items.
042 - 3. From the table of allowances.

043 - 1. Unserviceable (Reparable) Tag—Materiel, DD Form 1577-2.
043 - 2. Serviceable Tag—Materiel, DD Form 1574.
043 - 3. Items whose repair costs exceed 75 percent of the item's original cost are condemned. A DD Form 1577 tag is used.
043 - 4. Serviceable DD Form 1574.

044 - 1. Allows uninterrupted repairs and speeds up the return of repair parts to their users.
044 - 2. Supply personnel.
044 - 3. The shop.
044 - 4. Order the item from Demand Processing using normal issue procedures.

045 - 1. Consolidate index of all USAF equipment allowance documents.
045 - 2. To find out what tools are authorized in a toolkit.
045 - 3. To check the types and amount of equipment authorized in a sheet metal and plastic shop.
045 - 4. Coordinate with Material Control to substantiate the need for this equipment, then acquire the equipment.

046 - 1. You are responsible.
046 - 2. SSgt Jones is accountable.
046 - 3. All personnel who use the equipment are responsible for its care.

047 - 1. The property you use in the completion of your work is your responsibility, even if its accountability lies with someone else.
047 - 2. Supervisory responsibility applies to any person who exercised supervision over property received, in use, in transit, in storage, or undergoing modification or repair.
047 - 3. A DD Form 362 is used when a person admits pecuniary liability for an item but doesn't have the cash to pay for it.
047 - 4. A DD Form 1131 is used when a person admits pecuniary liability for an item and desires to pay cash.

048 - 1. DD Form 200.
048 - 2. Immediately after it is known that the loss, damage, or destruction of property has occurred and no one will admit liability.
048 - 3. The liable person must reimburse the Air Force.
048 - 4. He uses DD Form 1131, Cash Collection Voucher, or DD Form 362, Statement of Charges.

CHAPTER 4

049 - 1. Highly qualified in leadership, management, and administration.
049 - 2. He manages, plans, controls, executes, and produces the work needed to fulfill the mission of the maintenance organization.
049 - 3. Direction and guidance.

050 - 1. Job Control, Plans and Scheduling and Documentation, and Materiel Control.
050 - 2. a. Materiel Control.
b. Plans and Scheduling and Documentation.
c. Job Control.
d. Plans and Scheduling and Documentation.
e. Materiel Control.
f. Job Control.
g. Plans and Scheduling and Documentation.
h. Materiel Control.
i. Plans and Scheduling and Documentation.
j. Materiel Control.

051 - 1. Deficiency analysis, inspection, standardization-evaluation, weight and balance, technical order library, functional check flight and deficiency reporting.
051 - 2. a. Deficiency analysis.
b. Inspection.
c. Deficiency reporting.
d. Standardization-evaluation.
e. Deficiency analysis.
f. Functional check flight.
g. Technical order library.
h. Weight and balance.

052 - 1. 1. c.
2. b.
3. a.

4. c.
5. a.
6. b.
7. b.
8. c.
9. a.
10. b.

052 - 2. a. Programs and Mobility.
b. Production Analysis.
c. Administration.
d. Production Analysis.
e. Administration.

053 - 1. a. AMS.
b. FMS.
c. OMS.
d. FMS.
e. MMS.
f. FMS.
g. OMS.
h. AMS.
i. OMS.
j. FMS.

053 - 2. 1. c.
2. b.
3. a.
4. b.
5. c.
6. b.
7. d.
8. b.
9. a.
10. c.

054 - 1. 1. Organizational.
2. Intermediate.
3. Organizational, Intermediate, and Depot.
4. Depot.
5. Intermediate.

055 - 1. 1. Preflight inspections are performed before the first flight of the day, when an aircraft goes into and out of alert status, and when an airline type of aircraft remains on the ground until the next calendar day.
2. To determine if the aircraft is suitable for another flight.
3. After a specified number of flying hours have accumulated.
4. When the specified number of flying hours or calendar period has expired.
5. When cargo aircraft is utilized for regular airline type operations.

056 - 1. Combination of the basic postflight and/or hourly postflight and periodic inspection requirement into small packages.
056 - 2. To reduce the "out of commission" time of the aircraft.
056 - 3. The amount of flying time accured.

057 - 1. Home station check.
057 - 2. Minor and major inspections.
057 - 3. A basic postflight or home station check is required.
057 - 4. A hourly postflight inspection or home station check, plus performance of an operational check of all functional aircraft systems.

058 - 1. Inspections accomplished at the aircraft on the flightline are called the inplace method.
058 - 2. The "dock" method is accomplished at a specially prepared site, such as a large maintenance hangar.

059 - 1. To indicate the condition of the aircraft.
059 - 2. a. Red diagonal.
b. Circled red X.
c. Red X.
d. Red dash.
e. Black last name initial.
f. The letter C inside a red circle.

060 - 1. Left-hand column entries:
a. SYM.—Red X.
b. Date Discd.—01/07/5.
c. WDC—F.
d. JCN—1830066.
e. Discrepancy—Loose rivets in the intake of No. 2 engine.
f. Discovered By—H. Jones, A1C.

Right-hand column entries.
a. Corrective Action—Replaced loose rivets in No 2 engine intake.
b. Date Corrected—01/07/5.
c. Corrected By—A. Smith, Sgt.
d. Inspected By—H. Madison, MSgt (who entered his first initial of his last name in the SYM block, in the left-hand column).

061 - 1. Determine problem areas and manpower and spare parts requirements.
061 - 2. Accurate recording of data on the maintenance forms.
061 - 3. "On-equipment" documentation.
061 - 4. "Off-equipment" documentation.
061 - 5. Productive indirect.

062 - 1. The individual performing the maintenance records the maintenance accomplished on the AFTO Form 349.
062 - 2. Maintenance Data Collection System.
062 - 3. Record maintenance actions and serve as a dispatch notice.
062 - 4. Any part defective or thought to be defective.
062 - 5. Part 1, processing document.
Part 2, schedule control document.

063 - 1. Job Control Number—016-0003.

064 - 1. The workcenter code to be recorded in block 2 of figure 1, foldout 1, is A3130.

065 - 1. So that an accurate account of maintenance performed on a specific piece of equipment is maintained.
065 - 2. a. A.
b. B.
c. 6153.
065 - 3. Enter AA3407 in block 3.

066 - 1. To identify a specific item being repaired.
066 - 2. No, because an I.D. No./Serial No. is shown.

067 - 1. Job Control.
067 - 2. a. 1.
b. 3.
c. 2.
d. 2.
e. 1.
067 - 3. Priority 2.

068 - 1. When the AFTO Form 349 is used as a dispatch form.
068 - 2. Type maintenance that you'll be performing, other maintenance being performed at the same time, and the length of time it will take you to complete your job.
068 - 3. The average time it takes to accomplish a certain job.
068 - 4. 0930—show time; 3.0 standard.

069 - 1. The description in block 26 must agree with the entries made in blocks C and F.
069 - 2. A brief and accurate description of the discrepancy.

070 - 1. No. A brief, but accurate account of the maintenance performed must be entered.
070 - 2. Action Taken, column D.
070 - 3. For additional space needed for blocks 26 and 27.

071 - 1. Indicates the type of work that was accomplished.
071 - 2. B, (Unscheduled).
071 - 3. Discrepancy is not on an engine.
071 - 4. 1311U.

072 - 1. Action Taken—G, When Disc—F, and How Malfunctioned Code—190.
072 - 2. When an item is bent, buckled, collapsed, dented, distorted, or twisted.
072 - 3. Used only when another "on-equipment" code will not fit the maintenance situation.
072 - 4. M.

073 - 1. 0.
073 - 2. Eight AFTO Forms 349 are completed; only one has 1 unit of work produced recorded.
073 - 3. (1) one.

074 - 1. Start Time—0935.
074 - 2. Columns:

G	*H*	*I*
0	0935	1130
1	1230	1330

074 - 3. Columns:

J	*K*
1	1
1	3

074 - 4. Two action line entries.

075 - 1. The 2-position command code of the owning command of transient aircraft or equipment with no I.D. number assigned.
075 - 2. To indicate maintenance accomplished on items based on the date of previous maintenance.
075 - 3. Columns:

L	*M*	*N*
Blank	Blank	J8934
Blank	Blank	S6136

076 - 1. Identifies status of the reparable item, provides a source document for information, and provides a means for controlling the flow of items to and from the maintenance shops.
076 - 2. Blocks 1 through 14.
076 - 3. Block 1—0160003.
Block 2—AA3407.
Block 3—B.
Block 4—F.
Block 5—190.
Block 6—C-130A.
Block 7—1311U.
Block 9—1.
Block 10—1560.
Block 11—35678-1A.
Block 14—"Bracket Assy. on the main landing gear retracting mechanism cracked."

077 - 1. AFTO Form 350.
077 - 2. Block 1—0160003.
Block 2—A3130.
Block 3—AA3407.
Block 7—2.
Block 19—1560.
Block 20—35678-1A.
Column A—B.
Column C—1311U.
Column D—A.
Column E—F.
Column F—190.
Column G—1.
Column H—1430.
Column I—016/1630.
Column J—1.
Column K—1.
Column N—J1374.
Block 26—"Bracket Assy. on the main landing gear retracting mechanism cracked."
Block 27—"Bench checked and repaired."
077 - 3. Block 15—"Installed patch on bracket assy.
Block 26—16 Jan 75, John Johnson.

078 - 1. Block 1—015-0030.
Block 2—A3130.
Block 3—AINDLB.
Column C—DTLOO.
CMPOO.
Column H—1300.
1230.
Column I—015/1500.
015/1630.
Column J—3.
1.
Column K—1.
2.

079 - 1. To establish methods that feed back deficiency data to activities responsible for an item so that corrective and preventive actions can be taken.
079 - 2. a. I; b. II; c. II; d. II; e. I; f. I; g. II; h. I; i. I; j. I.
079 - 3. Electrically on a DD Form 173, Joint Messageform.
079 - 4. By AUTODIN using SF Form 368 format.

080 - 1. They can be used to improve work methods and evaluate current working practices.
080 - 2. AFTO Form 95, Significant Historical Record.
080 - 3. Maintenance data collection reports.

CHAPTER 5

081 - 1. To insure the performance of the AF mission with the greatest possibility of success and the least chance of loss of life or damage to equipment.
081 - 2. AFR 8-2, *Air Force Technical Order (TO) System.*
081 - 3. Contains information, instructions, and safety procedures pertaining to the inspection, operation, maintenance, and modification of Air Force equipment and material.
081 - 4. TO 00-5-2, *Technical Order Distribution Systems.*
081 - 5. To become familiar with the TO system and use tech data in accomplishing maintenance.

082 - 1. d.
082 - 2. c.
082 - 3. a.
082 - 4. b.
082 - 5. c.
082 - 6. d.
082 - 7. e.
082 - 8. a.
082 - 9. b.
082 - 10. d.

083 - 1. To distinguish one technical order from another and provide a systematic grouping of technical publications.
083 - 2. The category of technical order.
083 - 3. The actual information that the technical order contains.
083 - 4. 1F-109B-3.
083 - 5. a. 1.
b. 34.
c. 2.
d. 3.
e. B.
f. 4.

084 - 1. 1 June 74.
084 - 2. Maintenance Documentation for In-Shop Eng Maint, OC.

084 - 3. Fighter Aircraft Technical Orders.
084 - 4. 30 Aug 75.

085 - 1. The category of technical order for a piece of equipment when you only know the name of the item.
085 - 2. By adding "0-1-" in front of the category found in the alphabetical index.
085 - 3. By gathering all the information you can about the equipment.
085 - 4. a. Locate the TO category in alphabetical index.
b. Add "0-1-" in front of category, developing specific NI&RT.
c. Turn to the table of contents for the specific NI&RT.
d. Locate specific piece of equipment in table of contents.
e. Turn to the pages indicated in NI&RT containing a listing of TOs for the piece of equipment.

086 - 1. Urgency of the information.
086 - 2. By an electrically transmitted message and is usually issued for immediate action and urgent action TCTOs.
086 - 3. a. Immediate Action TCTOs—Red X.
b. Urgent Action TCTOs—circled red Xs.
c. Routine Action TCTOs—none.
d. Interim TCTO—none.
086 - 4. A category 1 TCTO specifies that work be accomplished by field or organizational maintenance.
A category 2 TCTO specifies that work be accomplished by the depot during depot-level maintenance.
086 - 5. When the maintenance action required by the TCTO is not accomplished within the specific time periods.

087 - 1. Chief of Maintenance.
087 - 2. Because of the urgency of the information.
087 - 3. Mission priority.
087 - 4. They are colored green.
087 - 5. Immediately turn the kit back into the TCTO control section.

088 - 1. 1. b.
2. a.
3. d.
4. e.
5. c.
6. f.
7. g.
8. h.
9. b.
10. d.
088 - 2. Interim.
088 - 3. Formal.

089 - 1. The activity responsible for the corrective actions must respond within 48 hours either by issuing a TCTO or by disapproving or downgrading the report.
089 - 2. To recommond the correction of nonemergency TO deficiencies.
089 - 3. The person discovering the error in the TO.
089 - 4. The responsible activity must answer within 30 calendar days or within 20 days if the action cannot be completed within 30 days or if the report is disapproved or downgraded.
089 - 5. These reports are used to recommend improvements to TOs to correct potential hazards.

CHAPTER 6

090 - 1. The identification and elimination of accident causes.
090 - 2. Safety engineering involves controlling the work situation to minimize physical hazards.
090 - 3. Some people are a hazard to themselves and others because of their failure to comply with accepted safety standards.
090 - 4. Through adequate education and instruction.
090 - 5. Unsafe acts and conditions.
090 - 6. Unsafe personal characteristics of an individual.
090 - 7. The heredity and early environment of an individual.

091 - 1. AFR 127-101 provides practical accident prevention information and guidance to all Air Force personnel.
091 - 2. Smoking is not allowed within 50 feet or a hangar, fuel tank, parked aircraft, or area where flammable materials are stored.
091 - 3. To prevent electrical shocks or burns, and to remove the possibility of losing a finger if the ring should snag on something.
091 - 4. Loose clothing could get caught in moving machinery, and clothing that has been splashed with oil or solvent could ignite.
091 - 5. It is dangerous to personnel and can result in extensive damage to aircraft and equipment.

092 - 1. Keep floors clean and free of oil, grease, water, or other hazardous and slippery materials.
092 - 2. Oily rags should be disposed of in metal containers equipped with self-closing lids.
092 - 3. Cut the scrap metal small enough so as not to protrude out of the container.
092 - 4. Never cut small pieces of metal from the metal in storage.
092 - 5. a. Storage area should be in cool and dry place.
b. Provide ventilation to prevent fume buildup.
c. Identify acid and alkaline properly and store them separately.

093 - 1. Carelessness, poor housekeeping, poor storage practices, overloaded electrical outlets, and misuse of smoking materials.
093 - 2. Class A—wood, paper, textiles; Class B—oil, greases, paints; Class C—live electrical equipment.
093 - 3. 1. B and C.
2. A.
3. B and C.
4. A.
5. A.
6. B and C.
7. A and B.
093 - 4. 3; 6.

094 - 1. Color coding of machinery parts, the grounding of electrical equipment, the guarding of moving machinery, and safety inspections.
094 - 2. Movable.
094 - 3. When the machine is off.
094 - 4. Have it checked out.
094 - 5. Know how to operate your equipment.

095 - 1. Use the right type hammers for a given job.
095 - 2. People don't know how to use them properly.
095 - 3. a. Always use a file handle.
b. Clamp the item being filed into a vise.
c. Don't use file for prying.
095 - 4. Goggles and rubber guard.
095 - 5. When they are of the explosion-proof design.
095 - 6. a. Don't point the tool at anyone.
b. Don't change rivet sets without first turning off the air.
c. Don't use compressed air to remove dirt or dust.

096 - 1. When there is the probability of flying objects.
096 - 2. Gloves and safety toe shoes.
096 - 3. Respirator.
096 - 4. Because of the high noise level.
096 - 5. Safety toe shoes.

097 - 1. Stop and wait for a green light.
097 - 2. You must clear the area of personnel and equipment.
097 - 3. Insert your ear plugs.
097 - 4. Insert your ear plugs.
097 - 5. Leave the area until the radar operation is completed.

098 - 1. a. Work platform is free of oil, grease, etc.
b. All locks work.
c. Guard rails are in place.

098 - 2. Stay out if you have no business in the cockpit.

098 - 3. Install safety locks to prevent movement, and place a placard (sign) at the controls indicating maintenance is being accomplished and not to use the controls.

098 - 4. Ask someone who knows and have him check for you and at the same time show you the location.

098 - 5. To prevent damage to areas not constructed to be stepped on.

099 - 1. To reduce the amount of damage caused by foreign objects.

099 - 2. a. Stone—natural and unnatural.
b. Metal.
c. Miscellaneous.

099 - 3. a. Walkdown.
b. Proper clothing.
c. Tool inventory.
d. Repair parts inventory.
e. Removal of personal items from clothing.

099 - 4. Every maintenance man.

099 - 5. Stones.

099 - 6. Removal of personal items from clothing.

100 - 1. Mishaps on ground or water involving Air Force personnel or property, on or off an Air Force installation.

100 - 2. Total disability (even if temporary) and/or property damage.

100 - 3. When one or more fatalities five or more disabling injuries, or $10,000 or more in property damage occurs.

100 - 4. So that the Air Force can take corrective action and do what is necessary to prevent recurrence.

100 - 5. The installation ground safety office, acting for the investigating commander.

100 - 6. Within 8 hours.

100 - 7. Aid the injured, evacuate the area if additional injury is likely, and notify your supervisor as soon as practical.

100 - 8. As a nondisabling injury and in accordance with command directives.

100 - 9. As a major ground accident. A message is transmitted to concerned activities within 8 hours and is followed by a formal report within 30 calendar days.

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MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. EQ/CL	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION

10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD.

19. FSC	20. PART NUMBER	21. SER NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N EMPLOYEE NUMBER
1															
2															
3															
4															
5															

26. DISCREPANCY

27. CORRECTIVE ACTION

28. RECORDS ACTION

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Figure 1. Maintenance Data Collection Record.

TYPE MAINTENANCE CODES

CODE DESCRIPTION

TYPE MAINTENANCE CODES FOR AIRCRAFT, DRONES, INSTALLED ENGINES AND RELATED MOBILE TRAINING SETS (MTS) AND RESIDENT TRAINING EQUIPMENT (RTE). ENGINE SHOP CODES ARE INCLUDED FOLLOWING THIS LIST OF CODES.

A SERVICE

INCLUDES ALL UNITS OF WORK ASSOCIATED WITH SERVICING, CLEANING AND MOVEMENT OF EQUIPMENT.

B UNSCHEDULED MAINTENANCE -

INCLUDES ALL UNITS OF WORK ACCOMPLISHED BETWEEN SCHEDULED INSPECTIONS EXCEPT AS PROVIDED IN PRECEDING CODE A, AND EXCLUDING ACCOMPLISHMENTS OF TCTO'S.

C BASIC POSTFLIGHT OR THRUFLIGHT INSPECTION -

INCLUDES ALL UNITS OF WORK ACCOMPLISHED DURING ALL PHASES OF THE BASIC POSTFLIGHT OR THRU-FLIGHT INSPECTION.

D PREFLIGHT INSPECTION -

INCLUDES ALL UNITS OF WORK ACCOMPLISHED DURING ALL PHASES OF A PREFLIGHT INSPECTION. FOR MOBILE TRAINING SETS AND RESIDENT TRAINING EQUIPMENT THIS INCLUDES ALL UNITS OF WORK ACCOMPLISHED DURING SCHEDULED INSPECTIONS SUCH AS DAILY, SAFETY, AND SERVICING INSPECTION, EXCLUDING PERIODIC INSPECTIONS.

E HOURLY POSTFLIGHT OR MINOR INSPECTION -

INCLUDES ALL UNITS OF WORK ACCOMPLISHED DURING ALL PHASES OF AN HOURLY OR MINOR (ISOCHRONAL) INSPECTION.

H HOME STATION CHECK -

INCLUDES ALL UNITS OF WORK ACCOMPLISHED DURING ALL PHASES OF A HOME STATION (ISOCHRONAL) INSPECTION.

J CALIBRATION OF OPERATIONAL EQUIPMENT (NOT PME) BY OWNING OR ASSISTING WORK CENTER -

EXCLUDES CALIBRATION ACTIONS BY PME CALIBRATING WORK CENTERS (SEE T.O. 00-25-06-4-1 FOR TYPE MAINTENANCE CODES FOR PME).

P PERIODIC, PHASED OR MAJOR INSPECTION -

INCLUDES ALL UNITS OF WORK ACCOMPLISHED DURING LOOK AND FIX PHASES OF PERIODIC, PHASED OR MAJOR INSPECTIONS, EXCLUDING ACCOMPLISHMENT OF TCTO'S.

Figure 2. Type maintenance codes.

T.O. 1C-130A-06

WORK UNIT CODE	
13000	LANDING GEAR
13100	MAIN LANDING GEAR
13110	MECHANICAL COMPONENTS
1311A	UPPER SHOE ASSY
1311B	LOWER SHOE ASSY
1311C	TRACK ASSY, RIGHT
1311D	TRACK ASSY, LEFT
1311E	TORQUE-STRUT
1311F	UPLOCK
1311G	DOWNLOCK
1311H	AIR FILLER VALVE
1311J	UPPER BUMPER STOP
1311K	LOWER BUMPER STOP
1311L	DRAG PIN
1311M	GEAR BOX
1311N	BALL
1311P	FRICTION WASHER
1311Q	MANUAL RELEASE CABLE
1311R	BELLCRANK ASSY, SHIMMER
1311S	TRUNNION
1311T	CLUTCH
1311U	RETRACTING MECHANISM BRACKET ASSY
1311V *	BALL SCREW ASSY (TCI)
1311W	TORQUE BOLT
1311X	JACK SCREW
1311Y	SCREW BRAKE
13112	DRAG PIN BUSHING
13111	STRUT
13112	PISTON
13113	HORIZONTAL TORQUE TUBE
13114	VERTICAL TORQUE TUBE
13115	RETRACTION BRAKE AND MANUAL GEAR BOX ASSY
13116	UPPER SWIVEL BRACKET
13117	SHELF BRACKET
13118	CHINE ANGLE
13119	NOC
13120	HYDRAULIC COMPONENTS
1312A	BLEED VALVE
1312B	RELIEF VALVE
1312C	"P" NUT
1312E	HOSE
1312G	SWIVEL JOINT
1312J	SHUT-OFF VALVE
1312L	BRAKE ASSY, LANDING GEAR RETRACTION
13121	ACTUATING MOTOR
13122	RESTRICTOR
13124	FLOW REGULATOR

WORK UNIT CODE	
13000	LANDING GEAR (CONT)
13100	MAIN LANDING GEAR (CONT)
13125	SHUTTLE VALVE
13126	CONTROL VALVE
13127	DUMP VALVE
13128	SELECTOR VALVE
13199	NOC
13200	NOSE GEAR
13210	MECHANICAL COMPONENTS
1321A	TORQUE SCISSOR, LOWER
1321B	DISCONNECT HANDLE
1321C	TOW FITTING
1321D	BEARING ANTI-FRICTION
1321E	BUSHING
1321F	UPLOCK
1321G	DOWNLOCK
1321H	NOSE GEAR CRANK
1321K	DRAG FITTING STRAP PN 337664-84
1321M	BRACE ASSY-DRAG
1321P	DRAG LINK BEARING INSERT
1321Q	STEERING COLLAR
1321R	TRUNNION
1321S *	TOW FITTING ATTACHING BOLT (TCI)
13217	AXLE
13211	STRUT
13212	PISTON
13213	LINK DRAG
13214	DISCONNECT PIN
13215	FULCRUM
13216	FILLER VALVE
13217	SIDE STRUT
13218	TORQUE SCISSOR, UPPER
13220	HYDRAULIC COMPONENTS
13220	SHUT-OFF VALVE
13221	CYLINDER ACTUATOR
13222	UPLOCK CYLINDER
13223	DOWNLOCK CYLINDER
13224	PRESSURE REDUCER VALVE
13225	RELIEF VALVE
13226	RESTRICTOR
13227	CHECK VALVE
13228	SHUTTLE VALVE
13299	NOC

Figure 3 TO 1C 130A 06 (Work Unit Code Manual)

ACTION TAKEN CODES (CONT)

CODE	DESCRIPTION (CONT)
	ION OR SALVAGE. THIS CODE WILL ALSO BE USED WHEN A CONDEMNED CONDITION IS DISCOVERED DURING FIELD MAINTENANCE DISASSEMBLY OR REPAIR.
E.	FOR FUTURE USE.
F.	REPAIR-NOT TO BE USED TO CODE "ON EQUIPMENT" WORK IF ANOTHER CODE WILL APPLY. WHEN IT IS USED IN A SHOP ENVIRONMENT, THIS CODE WILL DENOTE REPAIR AS A SEPARATE UNIT OF WORK AFTER BENCH CHECK. SHOP REPAIR INCLUDES THE TOTAL REPAIR MANHOURS AND INCLUDES CLEANING, DISASSEMBLY, INSPECTION, ADJUSTMENT, REASSEMBLY AND LUBRICATION OF MINOR COMPONENTS INCIDENT TO THE REPAIR WHEN THESE SERVICES ARE PERFORMED BY THE SAME WORKCENTER.
G.	REPAIRS AND/OR REPLACEMENT OF MINOR PARTS, HARDWARE AND SOFT GOODS. (SEALS, GASKETS, ELECTRICAL CONNECTORS, FITTINGS, TUBING, HOSE, WIRING, FASTENERS, VIBRATION ISOLATORS, BRACKETS AND ETC.). WORK UNIT CODES DO NOT COVER MOST NON-REPAIRABLE ITEMS. THEREFORE, WHEN ITEMS SUCH AS THOSE IDENTIFIED ABOVE ARE REPAIRED/REPLACED, THIS ACTION TAKEN CODE WILL BE USED. WHEN THIS ACTION TAKEN CODE IS USED, THE WORK UNIT CODE WILL IDENTIFY THE ASSEMBLY BEING SERVICED OR MOST DIRECTLY RELATED TO PARTS BEING REPAIRED/REPLACED. FOR EXAMPLE, IF AN ELECTRICAL CONNECTOR WAS REPAIRED AND WAS ATTACHED TO A RADIO TRANSMITTER, THE WORK UNIT CODE FOR THE TRANSMITTER WOULD BE USED WITH THIS ACTION TAKEN CODE. FOR PRECISION MEASUREMENT EQUIPMENT THIS CODE WILL BE USED FOR REPAIRS THAT DO NOT REQUIRE CALIBRATION OF THE REPAIRED ITEM (SEE CODE F).
H.	EQUIPMENT CHECKED-NO REPAIR REQUIRED (OR "ON-EQUIPMENT" WORK ONLY). ALL DISCREPANCIES WHICH ARE CHECKED AND FOUND TO REQUIRE NO FURTHER MAINTENANCE ACTION. THIS CODE WILL BE USED ONLY IF IT IS DEFINITELY DETERMINED THAT A REPORTED DEFICIENCY DOES NOT EXIST OR CANNOT BE DUPLICATED. MUST BE USED WITH HOW MAL CODE 799, 812 OR 948.
J.	CALIBRATED-NO ADJUSTMENT REQUIRED-USE THIS CODE WHEN AN ITEM IS CALIBRATED AND FOUND SERVICEABLE WITHOUT NEED FOR ADJUSTMENT OR IS FOUND TO BE IN TOLERANCE BUT IS ADJUSTED MERELY TO PEAK OR MAXIMISE THE READING. IF THE ITEM REQUIRES ADJUSTMENT TO ACTUALLY MEET CALIBRATION STANDARDS OR TO BRING IN TOLERANCE, USE CODE K.
K.	CALIBRATED-ADJUSTMENT REQUIRED-ITEM MUST BE ADJUSTED TO BRING IT IN TOLERANCE OR MEET CALIBRATION STANDARDS. IF THE ITEM WAS REPAIRED OR NEEDS REPAIR IN ADDITION TO CALIBRATION AND ADJUSTMENT, USE CODE F.

Figure 4. Action taken codes.

WHEN DISCOVERED CODES

CODE	DESCRIPTION
A.	BEFORE FLIGHT-ABORT-AIR CREW
B.	BEFORE FLIGHT-NO ABORT-AIR CREW
C.	IN-FLIGHT ABORT
D.	IN-FLIGHT NO ABOR.
E.	AFTER FLIGHT-AIR CREW
F.	BETWEEN FLIGHTS-GROUND CREW
H.	BASIC POSTFLIGHT (OR THRU-FLIGHT INSPECTION (WHICHEVER IS APPLICABLE)
J.	PREFLIGHT INSPECTION
K.	MINOR INSPECTION
L.	DURING TRAINING OF MAINTENANCE ON EQUIPMENT UTILIZED IN A TRAINING ENVIRONMENT. (USE ONLY FOR CLASS II TRAINING EQUIPMENT). THIS CODE SHOULD BE USED WHEN RECORDING MAINTENANCE OR DISCREPANCIES ON CLASS II TRAINERS.
M.	PHASED/ISOCHRONAL/MAJOR
P.	FUNCTIONAL CHECK FLIGHT
Q.	SPECIAL INSPECTION
R.	QUALITY CONTROL CHECK
S.	DEPOT LEVEL MAINTENANCE
T.	DURING SCHEDULED CALIBRATION
U.	NON-DESTRUCTIVE INSPECTION. INCLUDES OPTICAL, PENETRANT, MAGNETIC PARTICLE, RADIOGRAPHIC, EDDY CURRENT, ULTRASONIC, SPECTROMETRIC OIL ANALYSIS, ETC.
V.	DURING UNSCHEDULED CALIBRATION
W.	IN SHOP REPAIR AND/OR DISASSEMBLY FOR MAINTENANCE
X.	ENGINE TEST STAND OPERATION
Y.	UPON RECEIPT OR WITHDRAWAL FROM SUPPLY STOCKS
2.	DURING OPERATION OF MALFUNCTION ANALYSIS AND RECORDING EQUIPMENT OR SUBSEQUENT DATA ANALYSIS
3.	HOME STATION
4.	CORROSION CONTROL INSPECTION

Figure 5. When discovered codes.

HOW MALFUNCTIONED CODES (ALPHABETICAL LISTING)

CODE	DESCRIPTION
956	ABNORMAL FUNCTION OF COMPUTER MECHANICAL EQUIPMENT
704	ACCIDENTAL EXPLOSION OF, OR DAMAGE FROM, OR BOARD MUNITIONS
931	ACCIDENTAL OR INADVERTANT OPERATION, RELEASE OR ACTIVATION (USE CODE 386 IF ITEM WAS LOST IN FLIGHT)
127	ADJUSTMENT OR ALIGNMENT IMPROPER
709	ADMINISTRATIVE CODEMANATION
651	AIR IN SYSTEM
007	ARCING, ARCED
627	ATTENUATION INCORRECT
694	AUDIO AND VIDEO FAULTY
693	AUDIO FAULTY
731	BATTLE DAMAGE
658	BEARING DESTINATION (STATION) ERROR
710	BEARING FAILURE OR FAULTY
780	BENT, BUCKLED, COLLAPSED, DENTED, DISTORTED OR TWISTED
631	BIAS VOLTAGE INCORRECT
135	BINDING, STUCK OR JAMMED
303	BIRD STRIKE DAMAGE
838	B PLUS INCORRECT
070	BROKEN
963	BROKEN FILAMENT/CATHODE TERMINAL
719	BROKEN OR FRAYED BONDING OR GROUND WIRE
108	BROKEN FAULTY OR MISSING SAFETY WIRE OR KEY
720	BRUSH FAILURE/WORN EXCESSIVELY
900	BURNED OR OVERHEATED
080	BURNED OUT OR DEFECTIVE LAMP, METER OR INDICATING DEVICE
111	BURST OR RUPTURED
469	BUSHING WORN OR DAMAGED
969	CANNOT RESONATE INPUT CAVITY
025	CAPACITANCE INCORRECT
120	CHANGE OF VALUE
150	CHATTERING
910	CHIPPED
970	COOLANT LEAK
389	COMPRESSOR DAMAGED-REASON UNKNOWN
028	CONDUCTANCE INCORRECT
160	CONTACTS/CONNECTION DEFECTIVE
170	CORRODED-MILD TO MODERATE
667	CORRODED-SEVERE
190	CRACKED
971	CRACKED CATHODE BUSHING
605	CRAZED
029	CURRENT INCORRECT

Figure 6. How malfunctioned codes.

Foldout 1. Documentation for AFTO Form 349.

S T O P - 1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
53153 01 22
BASIC CONCEPTS AND PRINCIPLES ASSOCIATED WITH AIRFRAME REPAIR OPERATIONS

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you have to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If mandatorily enrolled student, process questions or comments through your unit trainer or OJT supervisor. If voluntarily enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: **NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE.** In parenthesis after each item number on the VRE is the Learning Objective Number where the answer to that item can be located. When answering the items on the VRE, refer to the Learning Objectives indicated by these Numbers. The VRE results will be sent to you on a postcard which will list the actual VRE items you missed. Go to the VRE booklet and locate the Learning Objective Numbers for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

MULTIPLE CHOICE

1. (001) To obtain help in heat-treating metals to specifications, a supervisor should contact a specialist in which metalworking specialty?

   a. Corrosion control.
   b. Sheet metalworking.
   c. Metal processing.
   d. Machining.

2. (002) A change in your skill level, changes which digit, or digits, of an AFSC?

   a. Fifth.
   b. Fourth.
   c. Third.
   d. The first three.

3. (003) AFSC 53173 identifies which skill level?

   a. Apprentice.
   b. Specialist.
   c. Technician.
   d. Superintendent.

4. (005) An apprentice airframe repairman is expected to

   a. supervise personnel.
   b. perform major repairs.
   c. know general repair principles.
   d. be skilled in areas of structural repairs.

5. (006) Which one of the following is <u>not</u> a duty of an airframe repair specialist?

   a. Bond honeycomb structures.
   b. Trim sheet metal parts.
   c. Repair plastic enclosures.
   d. Remove broken studs, screws and pins.

6. (007) The shop chief for an airframe repair shop is usually a

   a. superintendent.
   b. technician.
   c. specialist.
   d. apprentice.

7. (008) What are the primary functions of a metalworking superintendent?

   a. Supervision and management.
   b. Conducting on-the-job training and trainer evaluations.
   c. Supervising airframe repair and metal processing specialist.
   d. Performing repairs and inspections of honeycomb structure.

8. (010) "Serious damage could result to the nation," applies to what category of classified information?

   a. Top Secret.
   b. Secret.
   c. Confidential.
   d. Official Information.

9. (011) Storage of classified information depends upon the

a. type of material and size of safes and vaults available.
b. security category and number of documents.
c. mission and location of the base.
d. type of material and security category.

10. (011) The majority of security violations are the results of

a. carelessness.
b. ignorance.
c. over-confidence.
d. enemy spying.

11. (012) Selecting a mode of transmitting classified information depends on the

a. "need-to-know" factor of the receiver.
b. amount of information being sent.
c. cost and distances of the receiver.
d. classification of the information being sent.

12. (013) Before releasing classified information, the possessor of that information must first be certain that the person receiving information has

a. a security clearance.
b. a need for the information.
c. the right to the information.
d. the right and need for the information.

13. (014) What is the primary factor that separates good supervisors from bad supervisors?

a. Age.
b. Technical knowledge.
c. Leadership ability.
d. Appearance.

14. (010a) As an airframe repairman, you are a potential source of operational data for enemy intelligence collectors because of

a. your knowledge of airframe reapir procedures.
b. your involvement in mission planning.
c. the work areas you enter.
d. the classified information stored within the airframe shop.

15. (010a) The primary purpose of the Operations Security (OPSEC) Program is to ensure

a. all classified information is correctly classified.
b. operational success of our military activities.
c. methods used to start operational activities are done through secure channels.
d. operational war plans are stored correctly.

16. (017) Which one of the following is not included in organized problem solving procedures?

a. Weigh the facts.
b. Building a workers confidence.
c. Gathering the facts.
d. Take action.

17. (018) Which of the following best describes horizontal coordination?

a. Branch Chief to Shop Chief.
b. Shop Chief to Shop Chief.
c. Shop Chief to Shift Supervisor.
d. Shift Supervisor to Specialist.

18. (019) The priority of a job is determined by the

a. cost and manpower available.
b. cost and time to compelte the job.
c. effect it has upon the mission.
d. effect it has upon cost, time, and manpower.

19. (020) Maintenance and inspection reports and charts are used for all of the following except

a. scheduling leaves and passes.
b. ordering supplies and equipment.
c. establishing training requirements.
d. upgrade training evaluations.

20. (021) What is the primary factor in the justification of personnel or equipment?

a. Mission requirement.
b. Operational cost.
c. Location of closest base.
d. Environmental conditions.

21. (022) Assigning three specialists to a technician for supervision but having the specialist report to a superintendent is a violation of which principle of organization?

a. Span of Control.
b. Unity of Command.
c. Logical Assignment.
d. Delegation of Authority.

22. (023) Organizational and functional charts are useful because they

a. establish areas of responsibility.
b. point out personnel and equipment requirements.
c. indicate promotion sequence for specialist.
d. help to control cost factors related to aircraft maintenance.

23. (024) In selecting a worker to complete a speciific task, a supervisor should give the least consideration to

a. job priority.
b. work distribution.
c. personal appearance.
d. skill level and experience.

24. (026) The main rule to remember when evaluating a worker's performance is that the report must

a. be objective and impersonal.
b. establish causes for substandard areas.
c. point out outstanding and satisfactory areas.
d. state the working conditions at the time of the evaluation.

25. (029) The dual channel OJT concept consists of

a. standard procedures and special instructions.
b. career development courses and methods of training.
c. job proficiency requirements and job proficiency guides.
d. job proficiency requirements and career development courses.

26. (030) The shop supervisor's responsibilities include all of the following except

a. starting on-the-job training records.
b. slecting the best qualified trainers.
c. instructing trainers and trainees in the objectives of the OJT program.
d. providing guidance in methods of training and testing, in personal relations, and in good management principles.

27. (031) Which teaching method is the most effective in conducting OJT?

a. Lecture.
b. Discussion.
c. Demonstration.
d. Performance.

28. (031) When conducting OJT, you should always remember that the trainee learns best by

a. watching training film.
b. actually performing work.
c. reading.
d. demonstration.

29. (032) Qualification training occurs

a. before upgrading takes place.
b. after upgrading takes place.
c. during OJT.
d. concurrently with OJT.

30. (033) What is the purpose of the USAF Graduate Evaluation Program?

a. Establishes procedures for conducting training.
b. Develop qualification training standards.
c. Evaluate training received.
d. Evaluate on-the-job proficiency training.

31. (034) The purpose of Air Force Manual 67-1, USAF Supply System is to establish

a. bench stock requirements.
b. student-to-equipment class ratios.
c. a uniform system of stock control throughout the USAF.
d. a uniform system of supply bases only in foreign countries.

32. (035) In the national stock number 6945-00-174-4130, the Federal Supply Classification Code is identified by the digits

a. 00.
b. 6945.
c. 174-4130.
d. 00-174-4130.

33. (035) When using the Federal Supply Classification System to identify parts, the class code is designated by the

a. Third and fourth digits of the NSN.
b. Third and fourth digits of the NITN.
c. First two digits of the NSN.
d. Last seven digits of the NSN.

34. (036) Which cataloging handbook is the suggested index used for locating items withn an FSC class?

a. H2-1.
b. H2-2.
c. H2-3.
d. H6-1.

35. (036) Which cross-reference index lists all known approved identifying numbers in alphabetic-numeric sequence?

a. Manufacturer's Name and Address Index.
b. Manufacturer's Federal Code Index.
c. C-RL-2.
d. C-RL-1.

36. (037) If you know the manufacturer's part number and need to know the NSN and dimensions, which of the following would be the correct sequence of research?

a. C-RL-1 to IL catalog.
b. C-RL-2 to ML catalog.
c. H2-2 to IL catalog to GSA catalog.
d. H2-3 to IL catalog to GSA catalog.

37. (038) Which of the following is not a part of a supply document number?

a. Organizational Code.
b. Activity Code.
c. National stock number.
d. Serial number.

38. (039) Which of the following manuals outlines procedures for filling out supply request and turn-in forms?

a. AFM 50-23.
b. AFM 60-1.
c. AFM 67-23.
d. AFM 69-4.

39. (041) Which form requires your signature when supplies are received?

a. DD Form 1577-2.
b. DD Form 1577.
c. DD Form 1348-4.
d. DD Form 1348-1.

40. (042) In ordering initial or replacements of shop equipment, which form is used?

a. AF Form 601b.
b. AF Form 1297.
c. DD Form 1577.
d. DD Form 1577-2.

41. (043) Serviceable property is identified by a

a. green maintenance tag.
b. red maintenance tag.
c. DD Form 1442.
d. DD Form 1574.

42. (044) What is the main factor to consider before placing a supply item in bench stock?

a. The size and shape of the item.
b. The number of times the item is used.
c. The amount of items base supply has in storage.
d. Locations of bench stock bins in the maintenance shops.

43. (045) A consolidated index of all USAF equipment allowance documents commonly known as table of allowances (TAs) is located in

a. AFR 0-1.
b. AFR 0-01.
c. AFR 0-1-1.
d. AFR 0-10.

44. ((045) TAs sets the basic allowances for equipment and tools. What determines the actual equipment and tools within a shop?

a. Work requirements.
b. Number of shop personnel.
c. Size of shop and cost of equipment and tools.
d. Location of shop, whether in the United States or overseas.

45. (048) A Report of Survey is conducted when

a. any item is lost, damaged or destroyed.
b. a serviceable item is found on base.
c. pecuniary liability is not admitted.
d. the item involved cost less than $50.00.

46. (049) To qualify for the Deputy Commander for Maintenance position, an individual must

a. be at least the rank of major.
b. have flying experience in the aircraft on the base.
c. be highly qualified in aircraft construction and repair procedures.
d. be highly qualified in leadership, management and administration.

47. (051) The quality control branch is responsible for

a. developing maintenance pre-plans.
b. programming scheduled maintenance.
c. training personnel in quality workmanship procedures.
d. assuring the workmanship of the maintenance accomplished is acceptable.

48. (052) Financing and manning of the maintenance organization if performed by

a. Administration Section.
b. Programs and Mobility Section.
c. Production Analysis.
d. Production Control Section.

49. (053) The "owning" maintenance squadron for assigned aircraft is

a. AMS.
b. FMS.
c. OMS.
d. MMS.

50. (054) You are assigned to a Field Maintenance activity, what level of maintenance are you performing?

a. Intermediate.
b. Organizational.
c. Depot.
d. Supplementary.

51. (055) When is a basic postflight and hourly postflight accomplished at the same time?

a. After the last flight of the day for a specific aircraft.
b. After the specified calendar period has expired.
c. Before the first flight of day, the day for a specific aircraft.
d. When an aircraft has flown and accumulated a specified number of flying hours.

52. (056) The inspection concept designed to reduce the length of time an aircraft is out of commission is the

a. periodic.
b. phased.
c. isochronal.
d. intermediate.

53. (057) The type of inspection that is accomplished at equal intervals such as home station checks, minor check and major check is known as the

a. Periodic Inspection Concept.
b. Phased Inspection Concept.
c. Isochronal Inspection Concept.
d. Hourly Periodic Inspection Concept.

54. (059) What maintenance symbol is used to indicate that a functional flight check has not been accomplished?

a. Red X.
b. Red dash.
c. Circled red X.
d. Circled red letter.

55. (060) If you enter a maintenance symbol in error on the 781A, Aircraft Form, what must you do?

a. Erase the maintenance symbol entered in error and re-enter the correct symbol.
b. Transfer all entries on the page to a new page of the 781A, and destroy the one with the wrong symbol.
c. Make an entry in the corrective block indicating the symbol was entered in error--sign the corrected by block and initial over the erroneous symbol.
d. Make an entry in the Corrective block by indicating the symbol was entered in error--accomplish the required maintenance, sign the Corrected by Block and initial over the corrected symbol.

56. (061) The Maintenance Data Collection System indicates to maintenance managers the

a. jobs performed by assigned manpower.
b. maintenance required on equipment.
c. condition of equipment assigned.
d. jobs in progress by assigned manpower.

57. (061) The Maintenance Data Collection System

a. provides solutions for maintenance problems.
b. identifies problems for appropriate management actions.
c. identifies training requirements for maintenance personnel.
d. provides the Air Force with standard maintenance procedures.

58. (062) The AFTO Form 349 is a multipurpose form used to record

a. maintenance equipment required.
b. personnel availability.
c. aircraft availability.
d. maintenance action.

59. (064) What does the last digit of a workcenter code represent?

a. Identifies the squadron and command.
b. Points out the maintenance squadron.
c. Indicates the maintenance shop.
d. A subsection of the maintenance shop.

60. (066) The Equipment Classification Designator Codes are used to identify

a. general and individual items of equipment.
b. manufacturer's serial number and class code.
c. manufacturer's designation number and serial number.
d. equipment stock class and serial number.

61. (067) The priority number entered in block 7 of AFTO Form 349 establishes the

a. availability of personnel for jobs.
b. assignment of jobs in the shops.
c. mission essentiality of assigned jobs.
d. job standards and personnel authorized.

62. (068) When is the Time Specialist Required entered in block 17 of an AFTO Form 349?

a. Only when an AFTO Form 349 is used as a dispatch form.
b. When accounting for man-hours for flightline maintenance.
c. Before the maintenance is accomplished on reparable items.
d. Only when an item is removed from the aircraft by the specialist.

63. (070) The Corrective Action block description on an AFTO Form 349 when used for on equipment maintenance must agree with the

a. how malfunction code.
b. action taken code.
c. type maintenance code.
d. component position code.

64. (071) Refer to foldout 1. The code entered in column A of an AFTO Form 349, indicates

a. the type of maintenance that was accomplished.
b. when the discrepancy was discovered.
c. the level of maintenance performing the maintenance action.
d. which maintenance squadron discovered the discrepancy.

65. (072) To complete the Action taken block on AFTO Form 349, you would consult the

a. crew chief for the particular aircraft.
b. 781A AFTO form at the particular aircraft.
c. 06 code book for the particular aircraft.
d. -3 technical order for the type and model aircraft being repaired.

66. (072) The how malfunction code is used to identify

a. why equipment was damaged.
b. nature of repair required.
c. what equipment was damaged.
d. nature of equipment discrepancy.

67. (073) If you assist another workcenter in the completion of a job, the entry made in the Units block of your AFTO Form 349 would be

a. the number units you completed.
b. zero.
c. the total number of units completed.
d. one.

68. (075) When two or more individuals from the same workcenter are involved in a maintenance action, who's employee number is entered in Column N, Employee Numbers, on an AFTO Form 349?

a. Lowest ranking individual.
b. Individual who did the actual work.
c. Senior ranking individual.
d. Individual who makes the entries on the form.

69. (078) Which of the following is considered productive indirect labor?

a. Scheduled maintenance.
b. Unscheduled maintneance.
c. Maintenance training.
d. Refueling alert aircraft.

70. (079) Which factor determines the type of deficiency report submitted?

a. The cost of the deficient item.
b. The level of maintenance at which the deficiency was discovered.
c. The amount of maintenance required to correct the deficiency.
d. The effect the deficiency has on accomplishing the mission.

71. (081) Official Air Force publications which provide technical information, instructions, and safety procedures pertaining to Air Force equipment are known as

a. regulations.
b. technical orders.
c. manuals.
d. pamphlets.

72. (084) What type of technical order is indicated when the first part of the TO number is double zero (00)?

a. Specific procedures.
b. General information.
c. Overhaul instruction.
d. Alphabetical index.

73. (084) To find a listing of each of the different NI&RT indexes, use

a. TO 0-1-1.
b. TO 01-1-1.
c. TO 0-1-01.
d. TO 1-1-1.

74. (085) The index that contains a list of equipment cross-referenced to categories is the

a. alphabetical index.
b. cross-reference table TO 0-4-1.
c. cross-reference table TO 0-4-2.
d. numerical index and requirement table.

75. (086) The title page of an immediate action TCTO is identified by a border of

a. red diagonal.
b. circled red Xs.
c. red Xs.
d. red dashes.

76. (086) If an unsafe condition exists that could result in loss of life or damage to valuable proprty, what TCTO would you first receive?

a. Immediate Action TCTO.
b. Urgent Action TCTO.
c. Routine Action TCTO.
d. Interim TCTO.

77. (087) Incomplete TCTO kits will be

a. kept until space is received.
b. turned in within 10 days prior to due date.
c. stored as extra parts for other shortages.
d. turned in immediately upon determination of a shortage.

78. (087a) Which one of the following best describes the basis for determining which TOs will be included in an operational TO file?

a. All TOs the activity is likely to use in the next 5 years.
b. All TOs current for each type of operational aircraft assigned to the base.
c. Only the TOs required to accomplish the operational and maintenance responsibilities of the activity they serve.
d. Only the TOs that prescribe the operating procedures for assigned in-shop equipment.

79. (087b) Which of the following situations would generate a TO initial distribution requirement?

a. A lost copy of a TO must be replaced.
b. TOs must be ordered to operate and maintain new equipment.
c. Six copies of a TO are needed for a one-time training requirement within your shop.
d. A current change has <u>not</u> been received within 45 days of publication.

80. (087b) Who is responsible for transcribing TO requirements information from the AFTO Form 187 to key punch cards for AUTODIN Transmission?

a. Technical Order Distribution Office (TODO).
b. Technical order account representative.
c. Technical order subaccount representative.
d. The operational unit representative.

81. (087c) Which of the following entries on the AFTO Form 187 would cancel an initial distribution requirement level?

a. 0000 in the ID Qty Column.
b. 0000 in the Req Qty Column.
c. XXXX in the ID Qty Column.
d. XXXX in both the ID Qty and Req Qty Columns.

82. (087d) In which of the following situations should you initiate TO requisition follow-up actions?

a. 60 days have passed since you ordered a published TO from an overseas base and you have not received the TO or notification of a backorder.
b. 60 days have passed since you submitted your initial distribution request and the TO is still not published.
c. 60 days have passed since you submitted your initial distributiion request from an overseas base and the TO is still not published.
d. 60 days have passed since yo ordered a published TO from a Conus base and you have not received the TO or notification of a backorder.

83. (087c) It is necessary to use information found on an AFTO Form 215 to make entries on the AFTO Form 110 when recording data is related to

a. TOs received.
b. TOs backordered.
c. number changes and supplement for a specific TO.
d. One-time requisition of training TOs.

84. (087f) Which of the following is <u>not</u> part of the entry on the AFTO Form 131 to document a supplemental check?

a. TO numbers checked.
b. Number and data of the supplement to the NI&RT.
c. Date the check was completed.
d. Signature of the person making the check.

85. (087f) What should you inspect on the annual check that is not inspected on the supplement check?

a. The AFTO Form 110 File.
b. The AFTO Form 131 File.
c. The list of effective pages.
d. The contents of your TO file.

86. (089) What form would be used to submit a required change to technical order?

a. AFTO Form 22.
b. AFTO Form 341.
c. AFTO Form 349.
d. AFTO Form 350.

87. (090) Of the three methods used in the prevention of accidents, what is the most effective means to prevent unsafe acts by individuals?

a. Engineering.
b. Education and training.
c. Enforcement of safety standards.
d. Evaluation of technical order procedures.

88. (092) Which of the following is not a primary reason for storing metal in a rack?

a. Corrosion prevention.
b. Inventory purposes.
c. Accident prevention.
d. Metal identity.

89. (093) On what type of fire is a foam type fire extinguisher never used.

a. Oil.
b. Wood.
c. Grease.
d. Electrical.

90. (094) Air Force machine parts are color coded to

a. identify flammable parts.
b. indicate hi-value items.
c. denote stable and moving parts.
d. make Air Force equipment uniform in appearance.

91. (095) Handtools cause many accidents because they are

a. hand held.
b. improperly used.
c. the most numerous in a toolkit.
d. old and worn out from continuous use.

92. (095) It is preferable to use compressed air operated tools instead of electrically operated tools when

a. cost of air operated tools is cheaper than electrically operated tools.
b. electrical extension cords must be used.
c. tools must be used for a long period of time.
d. fire hazards are present.

93. (096) Which of the following is considered a standard part of a maintenance man's wardrobe?

a. Goggles.
b. Gloves.
c. Safety toe shoes.
d. Ear plugs and protectors.

94. (097) During transmissions your best protection against the radar radiation hazards is

a. distance.
b. protected equipment.
c. blast deflectors.
d. the two man maintenance concept.

95. (099) Relative to objects causing FOD, what is the primary cause of FOD in jet engines?

a. Miscellaneous.
b. Maintenance tools.
c. Personal items.
d. Stones and rocks.

96. (100) An accident on base involves a military and a civilian vehicle. It results in two temporary disabling injuries and $700 damage to the vehicles. How would the accident be classified?

a. A minor reportable ground accident.
b. A major reportable ground accident.
c. A command interest mishap.
d. A nondisabling injury.

97. (100) A major ground accident must be reported to the Director of Aerospace Safety within

a. 4 hours.
b. 8 hours.
c. 15 calendar days.
d. 15 working days.

STUDENT REQUEST FOR ASSISTANCE

PRIVACY ACT STATEMENT

AUTHORITY: 44 USC 3101. PRINCIPAL PURPOSE(S): To provide student assistance as requested by individual students. ROUTINE USES: This form is shipped with every ECI course package. It is utilized by the student, as needed, to place an inquiry with ECI. DISCLOSURE: Voluntary. The information requested on this form is needed for expeditious handling of the student's need. Failure to provide all information would result in slower action or inability to provide assistance.

SECTION I: CORRECTED OR LATEST ENROLLMENT DATA: MAIL TO: ECI, GUNTER AFS, ALA 36118

1. THIS REQUEST CONCERNS COURSE
2. TODAY'S DATE
3. ENROLLMENT DATE
4. PREVIOUS SERIAL NUMBER
5. SOCIAL SECURITY NUMBER
6. GRADE/RANK
7. INITIALS
LAST NAME
8. OTHER ECI COURSES NOW ENROLLED IN
9. ADDRESS: (OJT ENROLLEES - ADDRESS OF UNIT TRAINING OFFICE/ALL OTHERS - CURRENT MAILING ADDRESS)
ZIP CODE
10. NAME OF BASE OR INSTALLATION IF NOT SHOWN ABOVE:
11. AUTOVON NUMBER
12. TEST CONTROL OFFICE ZIP CODE/SHRED

SECTION II: Old or INCORRECT ENROLLMENT DATA

1. NAME:	2. GRADE/RANK:	3. SSAN:
4. ADDRESS:		5. TEST OFFICE ZIP/SHRED:

SECTION III: REQUEST FOR MATERIALS, RECORDS, OR SERVICE

(Place an "X" through number in box to left of service requested)

ADDITIONAL FORMS 17 available from trainers, OJT and Education Offices, and ECI. The latest course workbooks have a Form 17 printed on the last page.

1	EXTEND COURSE COMPLETION DATE. (Justify in Remarks)
2	SEND VRE ANSWER SHEETS FOR VOL(s): 1 2 3 4 5 6 7 8 9 - ORIGINALS WERE: NOT RECEIVED, LOST, MISUSED
3	SEND COURSE MATERIALS (Specify in remarks) - ORIGINALS WERE: NOT RECEIVED, LOST, DAMAGED.
4	COURSE EXAM NOT YET RECEIVED. FINAL VRE SUBMITTED FOR GRADING ON (Date):
5	RESULTS FOR VRE VOL(s): 1 2 3 4 5 6 7 8 9 NOT YET RECEIVED. ANSWER SHEET(s) SUBMITTED ON (Date):
6	RESULTS FOR CE NOT YET RECEIVED. ANSWER SHEET SUBMITTED TO ECI ON (Date):
7	PREVIOUS INQUIRY (ECI FORM 17, LTR, MSG) SENT TO ECI ON:
8	GIVE INSTRUCTIONAL ASSISTANCE AS REQUESTED ON REVERSE:
9	OTHER (Explain fully in remarks)

REMARKS: (Continue on Reverse)

OJT STUDENTS must have their OJT Administrator certify this request.	I certify that the information on this form is accurate and that this request cannot be answered at this station. (Signature)
ALL OTHER STUDENTS may certify their own requests.	

ECI FORM JUN 77 17 PREVIOUS EDITIONS MAY BE USED

SECTION IV: REQUEST FOR INSTRUCTOR ASSISTANCE

NOTE: Questions or comments relating to the accuracy or currency of textual material should be forwarded directly to preparing agency. Name of agency can be found at the bottom of the inside cover of each text. All other inquiries concerning the course should be forwarded to ECI.

VRE ITEM QUESTIONED:

Course No. _____

Volume No. _____

VRE Form No. _____

VRE Item No. _____

Answer You Chose (Letter) _____

Has VRE Answer Sheet been submitted for grading?

☐ YES ☐ NO

MY QUESTION IS:

REFERENCE
(Textual support for the answer I chose can be found as shown below)

In Volume No: _____

On Page No: _____

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Lines _____ Through _____

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53153 02 7704

CDC 53153

AIRFRAME REPAIR SPECIALIST

(AFSC 53153)

Volume 2

Fundamentals of Metalworking

Extension Course Institute

Air University

166

PREPARED BY
CHANUTE TECHNICAL TRAINING CENTER
USAF SCHOOL OF APPLIED AEROSPACE SCIENCES (ATC)
CHANUTE AIR FORCE BASE, ILLINOIS

EXTENSION COURSE INSTITUTE, GUNTER AIR FORCE STATION, ALABAMA

THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

IN THIS VOLUME of the airframe repairman course, the subject matter consists of the essentials—the backbone of our career field—in other words, the composition and the processing of aluminum, titanium, steels, and magnesium to obtain the desired end product.

Included in this discussion are materials identification, metalmarking, composition, physical properties, and working characteristics through heat-treatment. Also included are the differences in cutting, grinding, and forming of these metals. In addition, we cover corrosion control and prevention to assist you in prolonging the life of our materials and weapons systems.

Because of the time lapse between the achievement of the 3 and 5 levels of this career field, we include a comprehensive summary review of what you learned in the basic airframe course about the use of the layout tools, measurement equipment, handtools, and power equipment.

You will study the use and care of many powered and nonpowered tools, some of which you may not have access to while studying this course; but the working knowledges are essential to you for safe, economical, and reliable work performance on the job.

Take a little time to leaf through the pages of each chapter and look at some of the objectives. This will give you an idea of the scope of this volume and an insight into the organization of the material. We are using the singular pronoun *he, his,* and *him* in its generic sense, not its masculine sense. The word to which it refers is *person.*

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTOC, Chanute AFB IL 61868. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 54 hours (18 points).

Material in this volume is technically accurate, adequate, and current as of June 1976.

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NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Aircraft Construction Features

IN AVIATION'S early days, wooden aircraft structures, reinforced by metal accessories, were strong enough to withstand the vibrations and torsional stresses in slow-flying aircraft. Highly skilled woodcraftsmen maintained the wooden parts. Little metal repair was needed.

As aircraft speed and engine power increased, wood became unsatisfactory. Engineers and manufacturers realized that structural parts made from metal would have to replace wood, so they developed strong lightweight metal alloys. Structural forming and reinforcement methods were applied to save more weight and provide the strength required for high-speed flight and maneuvers.

The shift from wood to metal required a corresponding change to train maintenance personnel in metalworking instead of woodworking. Instead of having to know such details as the grain, strength, and weight of various woods, the repairman needed to know the characteristics of metals.

Unlike the woodcraftsmen's knowledge, your knowledge does not stop with metals and metal-working principles. In this age of high-speed aircraft, you must understand the principles of streamlining and fairing, aerodynamics, the behavior of various metals in high-velocity air currents, and the torsional stresses encountered during high-speed flying and maneuvering. In brief, you have to think of the aircraft in terms of high-speed performance.

Application of these principles involves selecting the kind of metal for structural strength and streamlining, the style of rivet to use, and the type of patch that will retain correct contour; determining how much weight can be added and still be within safe limits; and choosing the methods of structural forming and reinforcement to use. With the development of newer, lighter, and stronger alloys, you must keep abreast of such development.

This chapter begins by discussing the fundamental of flight aerodynamics. From there our discussion turns to the principal structural units of an aircraft. Lastly, we'll conclude with a brief look at the control surfaces employed on today's modern aircraft.

1-1. Basic Fundamentals of Aerodynamics

As an airframe repairman, you repair, fabricate, and modify aircraft structures. Although basic flight theory and aerodynamics were considered in full detail when the aircraft was designed, you should know this information and consider how a repair might be affected by these factors.

From time to time, you will have to repair the exterior surfaces of aircraft. The smoothness of repairs to these surfaces is limited only by your ability. Some of these are critical aerodynamic surfaces. They must be repaired so that the air will pass over them as smoothly as possible. Wing leading edges, wing upper and lower surfaces, and control surfaces are some of the more important areas which must be aerodynamically smooth.

You must make repairs that *are not only* structurally sound but also aerodynamically smooth. An understanding of the design and purpose of aircraft structures, along with the theory of flight principles, is important.

200. Describe the aerodynamic factors affecting the flight of an aircraft.

Aerodynamic Forces. Our purpose here is to consider the forces which contribute to aircraft lift and control. Four forces affect the aircraft lift and control in flight: gravity, thrust, drag, and lift. Let's review how they act on an aircraft.

Gravity. Gravity is the force which tends to draw an object toward the earth or hold it on the earth. To leave the ground and remain in flight, the aircraft must overcome the pull of gravity. A parked aircraft has only the force of gravity working upon it. Suppose, however, that this aircraft is at the end of a runway ready for takeoff. The next force it will need is thrust.

Thrust. Thrust is the forward force produced by the engine through the propeller or, in jet engines, by the reaction to movement of mass (air and exhaust gases). Thrust is the force that overcomes drag and inertia.

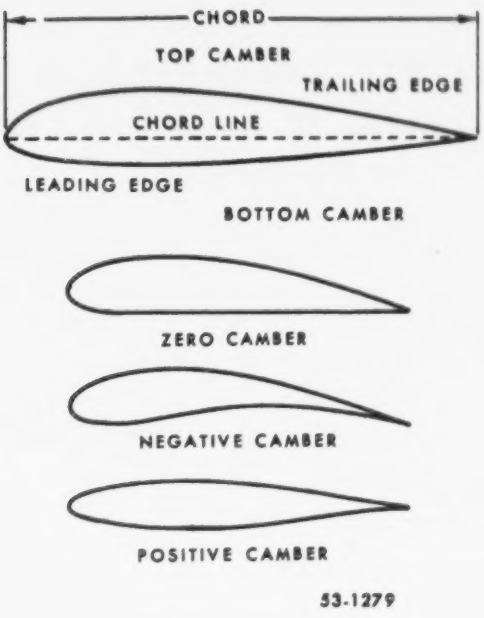

Figure 1-1. Airfoils in cross section.

Drag. Inertia is that property of matter which causes an object to remain stationary or in uniform motion in a straight line until compelled to change direction by a force acting upon it. In other words, if the aircraft is set in motion by applying the force of thrust, it will remain in motion, in a straight line, until a force is applied to stop it. This stopping force is present in the resistance of the air itself to an aircraft passing through it. This resistance of air represents a force which is called a drag.

Thrust, then, is the force which sets an aircraft in motion and keeps it in motion against the force of drag. Thrust can overcome the inertia of an aircraft to get it moving and can overcome the force of drag to keep it moving.

Lift. If the forces of gravity, thrust, and drag were the only ones acting on the aircraft, it would move down the runway until it ran out of runway or out of fuel. We need a force to overcome the pull of gravity and permit the aircraft to leave the ground. This fourth force, the one which works against the force of gravity, is called lift. As you already know, the wings are the part of an aircraft through which we obtain most of the lift.

Principles of Flight. The reason an aircraft flies is—quite simply—that it's shape acts on air to produce the needed lift. The following brief discussion describes the shape, and then shows how air reacts to it.

Airfoil. Let's first review and explain the term "airfoil." An airfoil is any surface built to obtain a reaction upon itself from the air through which it passes. From the standpoint of an aircraft, such things as propeller blades, wings, stationary and movable control surfaces, and even the fuselage are termed "airfoils." The term is usually applied, however, to the wings and empennage of an aircraft.

Figure 1-1 shows several cross-sections of wings or airfoils. The front edge of the wing is called the leading edge, and the rear the *trailing edge. The chord of* a wing is the distance from the leading edge to the trailing edge and is represented by a straight line called the chord line. The curve or departure from such a straight line (which the shape of the wing takes) is known as the camber. If the surface produces a convex (outward curving) surface, the camber is said to be positive. If concave (inward curving), the camber is said to be negative. The upper surface of an airfoil always has positive camber; the lower usually has positive camber also, but it can have zero (no curve) or negative camber.

Bernoulli's principle. In the 18th century a man named Bernoulli discovered that, as the speed of air moving over a surface increases, the pressure of the surface decreases proportionately. How does this fact apply to the flight of an aircraft? Let's see what happens when an airfoil moves through the air. (We describe the action *as if* the airfoil is standing still and the air is moving. That is not what happens, but the effect is the same.)

As movement starts, the mass of air molecules at the leading edge of the airfoil divides. Since the distance across the curved top surface is greater than that across the relatively flat bottom surface, the air molecules which go over the top must move faster than those going across the bottom in order to meet at the same time along the trailing edge. The faster airflow across the wing creates a lower pressure above the wing than below, as illustrated in figure 1-2.

The greater pressure below the wing tends to push into the lower pressure above. As long as air passes over the airfoil, this condition exists. This is lift. When the movement of air is great enough, the lift matches the weight of the airfoil and all attached portions of it, and supports the entire aircraft. As the speed of air across the wing increases even more, the lift exceeds the weight of the aircraft, and the aircraft rises.

Not all the air met by an airfoil contributes to lift. Some of it creates resistance or drag and hinders forward motion. Lift and drag, the two forces into which air resistance is converted, depend on the angle of attack, speed of the airfoil, air density, and shape of the airfoil or wing.

Angle of attack. The angle of attack is the angle between the chord line of the wing and its direction of motion relative to the air. Motion relative to the air, or relative airflow, is the direction of moving air in relation to the wing or airfoil.

Lift and drag increase with an increase in the angle of attack up to a certain point called the critical angle. At this point, drag suddenly overcomes lift, and, as a result, the aircraft stalls. Drag continues to increase. The cause of stalling is turbulence. Turbulence is created by eddies of air (burbling) which break up the pattern of airflow on the upper surface of the wing.

Speed of the airfoil. As the speed of the airfoil moving through the air increases, the difference in pressure between the upper and lower airflow layers increases. So lift increases with speed—but not necessarily in direct proportion to it.

Air density. The density of air at 18,000 feet is about one-half of that at sea level. Remember that air becomes thinner as altitude increases; so any aircraft flying at high altitudes must increase its speed to maintain level flight. An aircraft's flight is also affected by temperature increases. (Warm air is not as dense as cool air.)

Shape of an airfoil. The shape of an airfoil affects lift in many ways. The greater the camber of curvature, up to a certain point, the greater the lift. An airfoil with a smooth surface has more lift in relation to drag than one with a rough surface. A rough surface produces turbulence, which reduces lift and increases drag.

Exercises (200):

1. Why should you, as an airframe repairman, be concerned with flight aerodynamics?

2. Briefly describe the four forces that affect the flight of an aircraft.

3. What is an airfoil?

4. What factors determine the amount of lift and drag and airfoil develops?

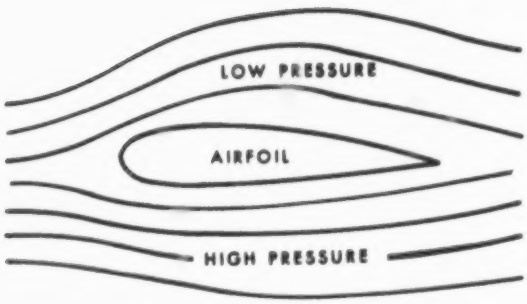

Figure 1-2. Lift.

1-2. Aircraft Construction Features

201. Name the types of fuselage constructions and describe the purpose of the individual structural units that are used to construct a fuselage.

Fuselage Construction. The fuselage is the main structural unit of the aircraft. Other structural units are directly or indirectly attached to the fuselage. From the standpoint of outline and general design, the fuselage of one type of aircraft is much the same as any other. Many different designs have been successfully tried for the many different USAF requirements and the most satisfactory features are still incorporated in the latest aircraft. Fuselage designs vary principally in size and arrangement of the different compartments.

The two basic types of fuselage construction are the truss and the monocoque. The truss type is a rigid framework made up of members such as beams, struts, and bars. It resists deformation by applied loads. The monocoque type is constructed like a shell. The skin of the fuselage bears the primary stresses. The strength of construction necessary depends upon the power used, speed, maneuverability, and design. The fabric-covered truss-framed fuselage is built for low power rating, slow speeds, and light construction. The truss type is used on many liaison aircraft and on small, light private aircraft. Figure 1-3 illustrates two kinds of truss-type construction.

The true monocoque type of construction is seldom used because the skin acts as the principal part of the airframe. As shown in figure 1-4, formers, frame assemblies, and bulkheads are used to give the shape, but the skin carries the primary stresses. Since no bracing members are present, the skin must be strong enough to keep the fuselage rigid. One of the big problems involved in monocoque construction is maintaining enough strength, yet keeping the weight within the allowable limits.

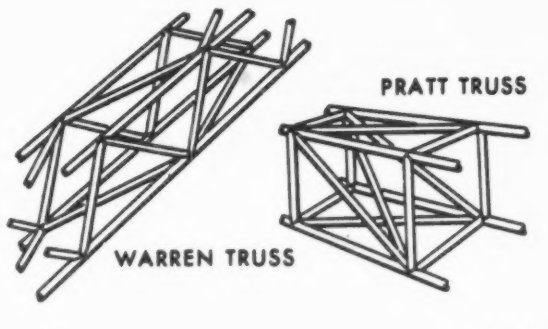

Figure 1-3. Truss-type of construction.

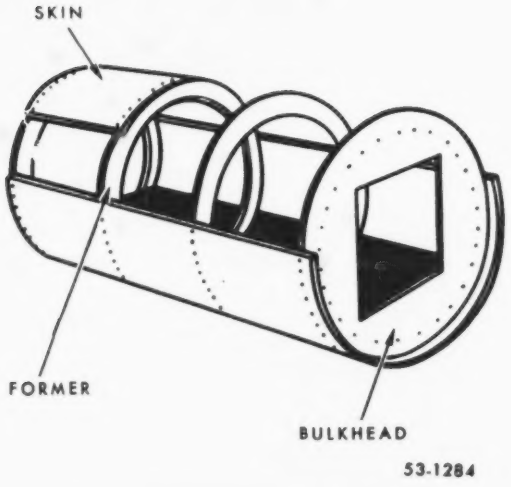

Figure 1-4. Monocoque-type of construction.

To overcome the strength-weight problem of monocoque construction a modification of it, called *semimonocoque,* was developed. This is used in the construction of nearly all present day military aircraft.

Structural Members. Bulkheads, frame assemblies, and formers serve the dual purpose of giving cross-sectional shape to the fuselage and of adding rigidity and strength to the structure. The shape and size of these members vary considerably, depending on their function and position in the fuselage. Formers are the lightest and are used primarily for fillings or skin attachments between the larger members. Frame assemblies account for most of the structural members in the fuselage; they contribute to both the appearance and strength of the structure. When frame assemblies are used to separate one area from another, they become circular discs, reinforced, and equipped with doors or other means of access, and are called *bulkheads.*

Bulkheads. Bulkheads are the oval-shaped members of a monocoque or semimonocoque fuselage which give form to and maintain the shape of the structure. They carry concentrated stress loads. There are various types of bulkheads, but the most common type is a curved channel formed from sheet stock with stiffeners added. Others consist of a web made from sheet stock with extruded angles riveted in place as stiffeners and flanges. Most of these members are made from aluminum alloys; however, corrosion-resistant steel formers are used in areas exposed to high temperatures. Bulkheads are identified by station numbers, which are helpful in locating repair information for a specific bulkhead. Figure 1-5 illustrates typical cross-sectional members of the fuselage.

Longerons. The longerons are the main lengthwise member of the fuselage. They are the "backbone" of the fuselage. Longerons are strong and heavy, holding the bulkheads and formers together in a rigid fuselage framework. Longerons usually run the whole length of the fuselage. Note the location of the longerons in figure 1-6.

Stringers. Stringers are smaller and lighter than longerons. They run longitudinally from the nose of the aircraft to the tail. They are used as fill-ins between the longerons and aid in riveting the skin to the fuselage. Compare the size and location of stringers to those of the longerons in figure 1-6.

Stringers or stiffeners are divided into two groups: those formed by regular forming methods and those that are extruded. Extruded angles are usually used for stringers because of their high strength-to-weight ratio. Extrusions are made by a process similar to the manner in which toothpaste is shaped when forced from a tube. An extruded angle stringer is produced by forcing hot metal through a die in which there is an opening corresponding to the desired cross-section shape of the stringer. The required cross-section shape or area is determined during the design stages of the aircraft by calculating the load the stringer will be required to support.

Formed stringers are made in numerous shapes by using various forming techniques on brakes or combinations of die presses. When stringers are formed by machine processes, they are made from annealed aluminum alloys and hardened by heat treatment after forming in order to obtain their maximum strength. Regardless of the method of manufacture, most stringers are made of 2024 or 7075 aluminum alloys.

Additional internal structures. Channel members, hat sections, and build-up assemblies are inserted to provide additional strength. Station webs are built-up assemblies located at various points for the attachment of fittings or external parts such as empennage surface fitting, engine mounts, wing attachments, and landing gears.

Skin. The smooth outer cover of the fuselage is referred to as the *skin.* The material used for the skin covering is usually a sheet aluminum alloy, either 2024T or 2017T, treated so that it will not corrode. Magnesium, titanium, and stainless steels are also used in certain areas. The thickness of the skin material depends on the load and stresses encountered in a given area. The skin carries primarily the shear load and, together with the longitudinal members, the loads of tension and bending stresses. Constant gage metal, machine milled, and chem-milled metals sections are the types of skin sections in use today.

Exercises (201):

1. What are the three types of fuselage construction?

2. What type of fuselage construction is used in present-day aircraft and why?

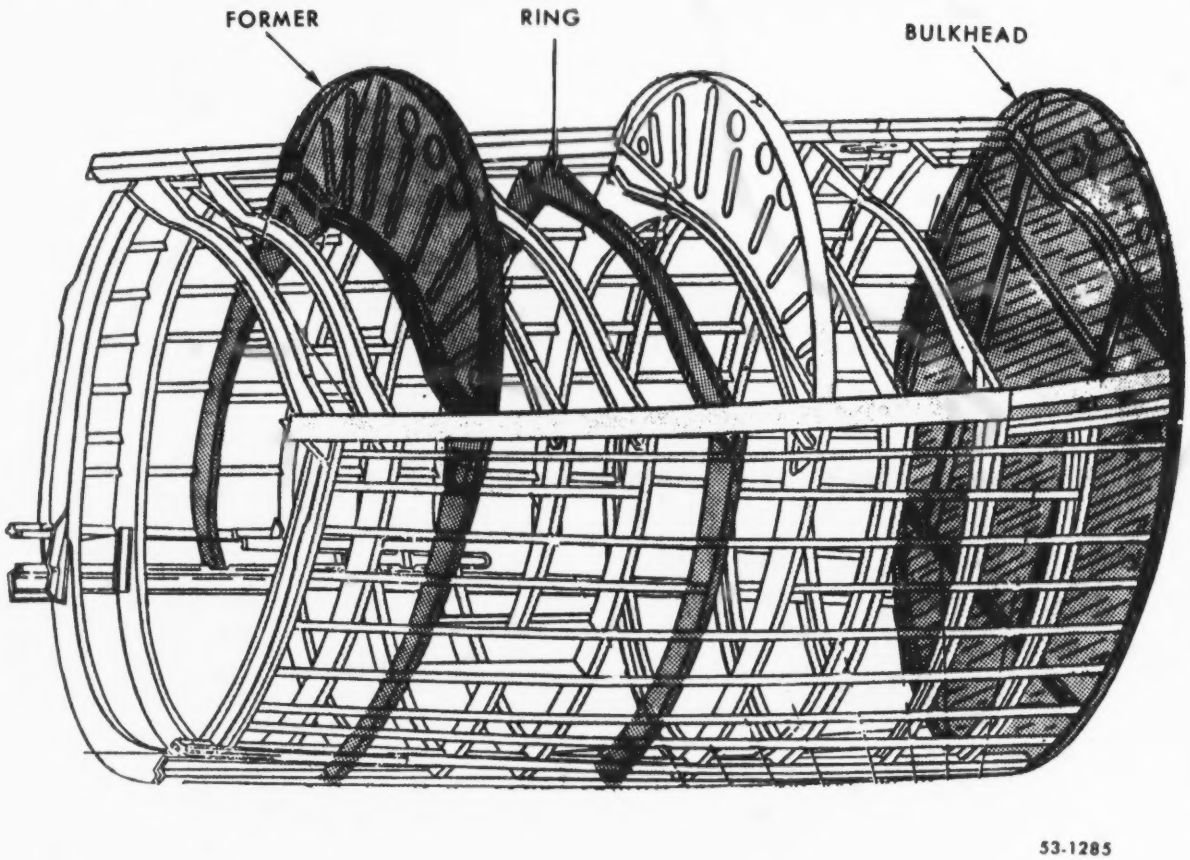

Figure 1-5. Aircraft fuselage construction, cross-sectional structural members.

3. What is the difference between a former and a bulkhead, and which one bears the heavier stress?

4. What is the difference between a longeron and a stringer and which bears the greater load?

5. What is an extruded stringer and what advantage does it offer?

6. Name the types of skin sections used in fuselage construction today.

202. Identify individual structural components of an aircraft wing and state the purpose of specified parts.

Wings. The wings of an aircraft are surfaces designed to give lifting force when moved rapidly through the air. The particular wing design for any given aircraft depends on a number of factors—such as size, weight, use of the aircraft, desired speed in flight and at landing, and desired rate of climb. The wings are designated as left and right, corresponding to the left and right hands of the pilot seated in the cockpit or the pilot's compartment. Engines mounted on wings are numbered from the left wing to the right.

Design. The wings of military aircraft are usually of cantilever design; that is, they are built so that no external bracing is needed. With few exceptions, wings of this design are of the stressed skin type, which means that the skin is a load-bearing part of the wing structure.

Wing construction. In general, wing construction is based on one of three fundamental designs—monospar (one), multispar (two or more), or box beam. Slight modifications of these basic designs may be adopted by various manufacturers.

The monospar wing incorporates only one main longitudinal member (spar) in its construction. Ribs or bulkheads supply the necessary contour or shape to

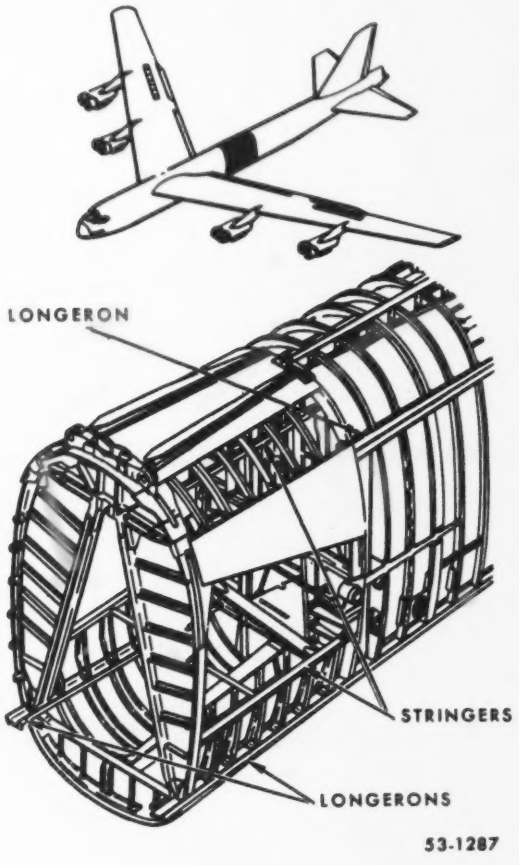

Figure 1-6. Longerons and stringers.

the airfoil. Although the strict monospar type wing is not common, this type of design, modified by the addition of false spars or light shear webs along the trailing edge as support for the control surfaces, is often used.

The multispar wing incorporates more than one main longitudinal member (spar) in its construction. To give the wing contour, ribs or bulkheads are often included. This type of construction, or some modification of it, is used in the lighter types of combat aircraft.

The box-beam type of wing construction uses two main longitudinal members with connecting bulkheads to furnish additional strength and to give contour to the wing. A corrugated sheet may be placed between the bulkheads and the smooth outer skin so that the wing can better carry tension and compression loads. In some cases, heavy longitudinal stiffeners are substituted for the corrugated sheets. A combination of corrugated sheets on the upper surface of the wing and stiffeners on the lower surface is sometimes used.

Other variations in wing design are necessary because of the angle at which the wing attaches to the fuselage. As shown in figure 1-7, wings angled upward have positive dihedral, and wings angled downward have negative dihedral. The wingtip may be square, rounded, or even pointed. Both the leading edge and the trailing edge of the wing may be straight or curved. In addition, one or both edges may be tapered so that the wing is narrower at the tip than at the root where it joins the fuselage. Numerous types of modern aircraft use sweptback wings.

Construction Features. The main structural parts of a wing—the spars, the ribs, stringers or stiffeners, and skin—are illustrated in figure 1-8. These structural parts are riveted or welded together.

Spars. Spars are the principal structural members of the wing. They correspond to the longerons of the fuselage. They run parallel to the lateral axis, or toward the tip of the wing, and are usually attached to the fuselage by wing fittings, plain beams, or part of a truss system.

The I-beam type of construction for a spar consists of a web (the deep wall plate) and cap strips (which in reality are extrusions or formed angles). These carry the loads caused by the wing bending, and also provide a foundation for attaching the skin. Stiffeners give additional strength to the spar structure. Stiffeners may be beads pressed into the web or extrusions or formed angles riveted to the web, either vertically or diagonally. Detail A of figure 1-8, shows a typical I-beam type of spar.

Ribs. Ribs are the crosspieces that make up the framework of the wing. They run from the leading edge toward the trailing edge (front to rear) of the wing. The ribs are secured to the spars, and since they are curved, they give the wing its aerodynamic shape

Figure 1-7. Wing design.

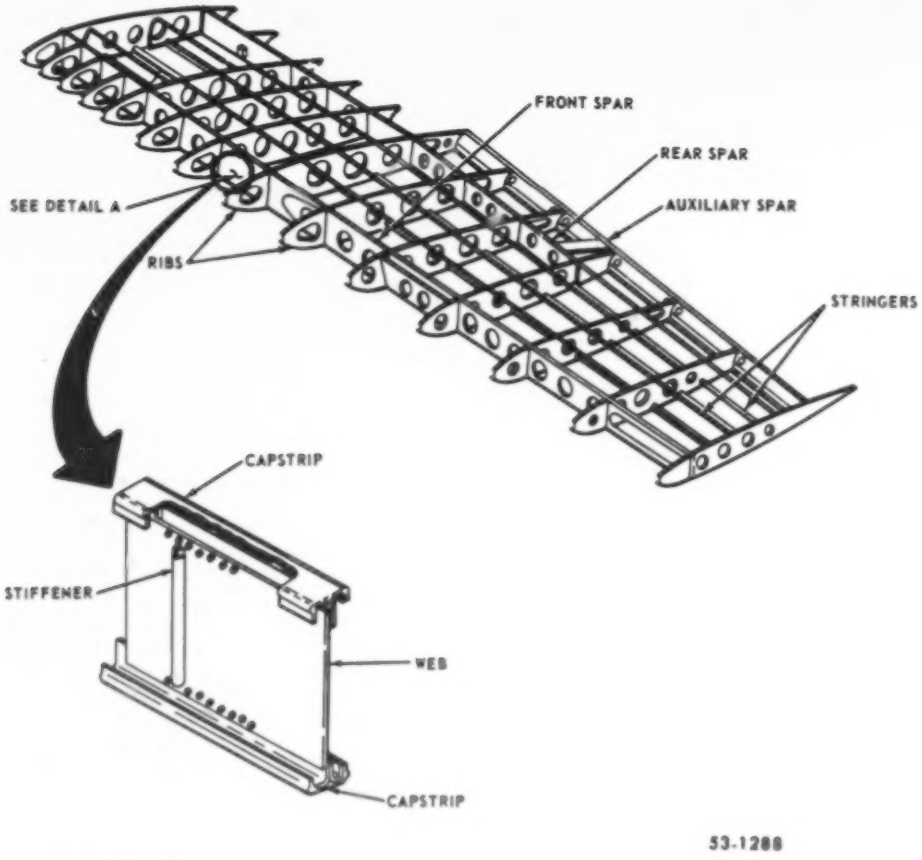

Figure 1-8. Interior wing construction features.

when it is covered with the skin. Ribs transmit the load from the skin to the spar. There are two general types of ribs construction, as shown in figure 1-9. The reinforced rib is relatively heavy as compared to the formed rib, and is located only at points where the greatest stresses are imposed. Formed ribs are located at frequent intervals through the wing. The reinforced rib is similar in construction to spars, consisting of upper and lower capstrips joined by a web plate. The web is reinforced between the capstrips by vertical and diagonal angles.

Formed ribs are made of formed sheet metal and are very light in weight. The bent-up portions of a formed rib is referred to as the flanges, and the vertical portion is called the web. The web is constructed with lightening holes, with beads formed between the holes. The lightening holes lessen the weight of the rib without decreasing the strength. Flanging the edges of the lightening holes helps maintain the rigidity of the web. The beads stiffen the web portion of the rib.

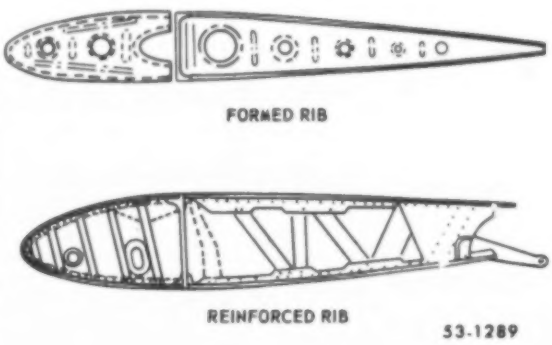

Figure 1-9. Types of rib construction.

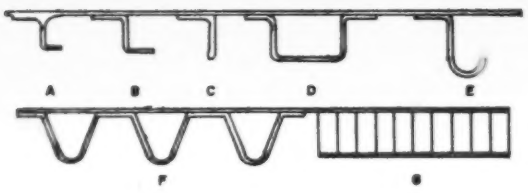

Figure 1-10. Typical methods of stiffening panels.

Stringers. Stringers or stiffeners are attached to the skin where high compressive loads are encountered, or where a shape must be held. These are usually found closely spaced on the under side of the upper wing skin. Where stiffening demands become extreme, the skin is usually reinforced by a corrugated panel or honeycomb sandwich instead of individual stringers. Cross sections of typical stiffened panels are shown in figure 1-10.

Skin. The skin used as wing covering is quite strong in tension and shear. The skin is employed as a primary load-carrying member in wing construction. The thickness of wing skin varies widely, depending upon the stresses encountered. Thicknesses vary from as low as .016 inch in small aircraft to as much as .750 inch in the wings of heavy bombers. If weight reduction is of prime importance, the skin is tapered so that the proper amount of strength is provided.

In the last few years, machine milled skins (fig. 1-11) have become routine in the aircraft industry. Many parts on high performance aircraft have been redesigned for machine milling. This process results in fewer parts, fewer fasteners, decrease in weight, easier assembly, greater load carrying capacity, and easier field repairs. Many different machines are required to machine mill skins. They include vertical milling machines, horizontal milling machines, detail milling machines, drilling machines, and routing machines.

Chem-milling is a process used to shape metals to an exacting tolerance by chemical removal, or deep etching, rather than by conventional mechanical milling or machining operations. Originally developed as a means of providing increased metal thickness at the edges to be butt-welded, the chem-mill process has mushroomed into a full-scale production tool. Designs which were once avoided as impossible to produce, or prohibitive in cost, are being achieved daily in chem-milling facilities.

Chem-milling, or etching, is the immersion of a part in an etching solution to remove metal and leave a predetermined design. The etching solution dissolves the metal not only in a direction perpendicular to the exposed surface, but also undercuts the mask. That is, the solution cuts underneath the mask approximately as far as it cuts into the metal. A series of tanks filled with special solutions are arranged to allow a rapid transfer of parts from one to another as etching and rinsing proceeds. The depth of metal removed depends on the time of immersion in the etching solution.

Honeycomb panels are also used as skin covering on certain sections of the wing. The type of honeycomb assemblies most commonly used consists of a honeycomb core of aluminum foil and then aluminum facing material bonded together with an adhesive. You can recognize honeycomb assemblies by their thin outer skin, the absence of fasteners, and the light weight of the complete assembly. Figure 1-12 shows one type of honeycomb skin panel assembly.

Wing sections. The leading edge, center section, and trailing edge section are the three sections that make up an aircraft wing (front to rear). The leading edge is the front section of the wing. The purpose of the leading edge is to streamline the forward section of the wing. The space within the leading edge is sometimes used to house extra equipment such as landing lights, plumbing lines, or thermal anti-icing systems. Leading edges constructed with thermal anti-icing systems consist of two layers of skin separated by a thin airspace.

The center section of the wing is from the front spar to the rear spar. This is the main structural section of the wing. All external structures are attached to this section. The space within this section is sometimes used to store fuel and on fighter type aircraft, this space serves as housing for the landing gear. The center section is where the wing walkway areas are located.

The trailing edge section is the rearmost part of the wing. Attachments for the control surfaces are located within this section.

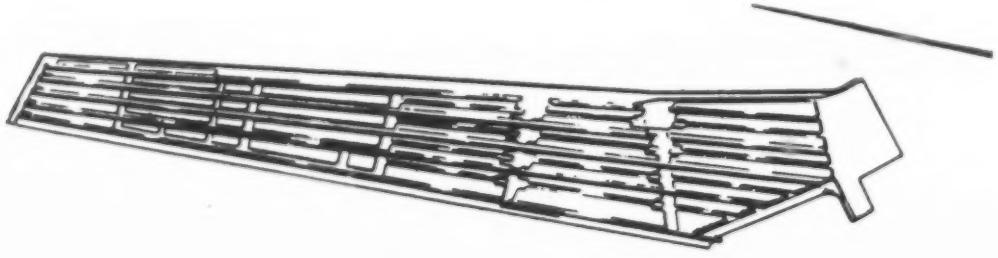

Figure 1-11. Chemical milling. 53-1291

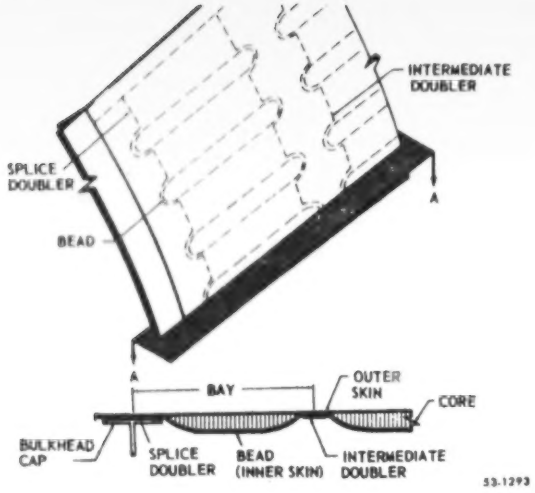

Figure 1-12. Bonded bead skin panel.

External structures. On multiengine type aircraft, the streamlined structural units placed around the aircraft engines to provide a smooth surface for airflow are called nacelles. The nacelles on jet aircraft are attached to a strut which in turn is attached to the center section of the wing. Figure 1-13 depicts this type of design.

On propeller driven aircraft, the nacelle is built as the part of the wing itself. Figure 1-14 illustrates the internal structural units for a built-in type nacelle. The construction features are similar to that of the fuselage.

On twin-engine aircraft, the nacelles also house the wing landing gears and related equipment. On a four-engine aircraft, the landing gear is enclosed in the inboard nacelles. An engine cowling with quick release type fasteners and latches provides access to the engine within the nacelle.

Fairings. Fairings are auxiliary members that streamline various parts and locations on the aircraft to reduce drag. They cover the joints formed where wing sections meet the fuselage and where the vertical and horizontal stabilizers mount on the main structure. They are often used to streamline around fittings, navigation lights, landing gear struts, wheels, and the like. Fairings are not strength members and are not intended to carry any of the principal loads placed on the aircraft structures.

Exercises (202):

1. What is the main structural part of an aircraft wing?
2. What type of wing design is used on almost all military aircraft today?
3. Which type of wing construction is used in lighter types of combat aircraft?
4. Name the individual parts of an I-beam type of spar construction.
5. Why are ribs used in wing construction?
6. Where are you likely to find reinforced ribs?
7. State two reasons for using stringers in wing construction.
8. Describe the three sections of the wing.

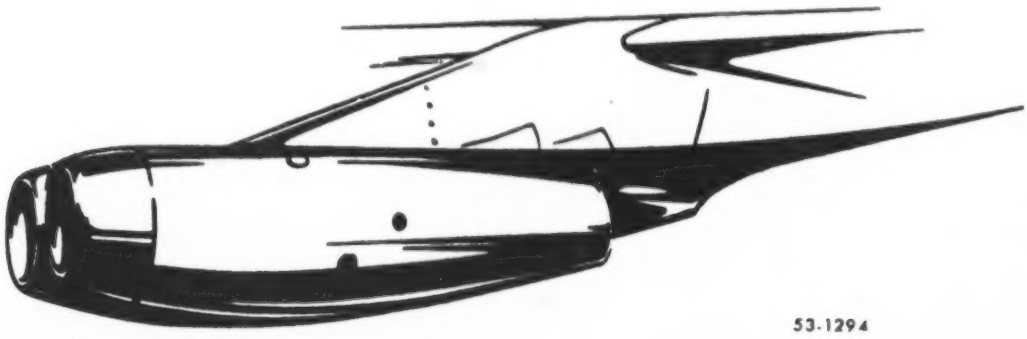

Figure 1-13. Jet engine nacelle.

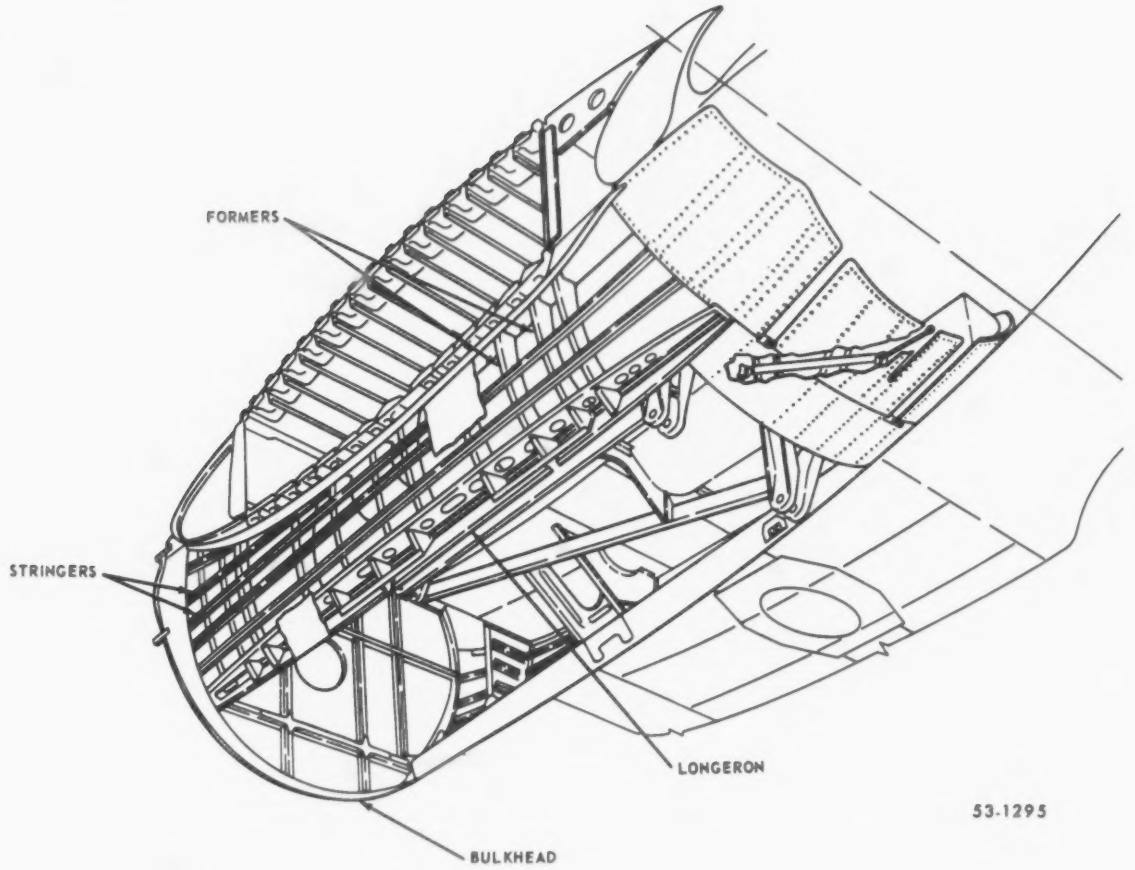

Figure 1-14. Built-in nacelle construction.

9. Why are fairings used in wing construction?

203. Identify the components of an aircraft empennage and their purpose.

The empennage is simply the tail section of the aircraft. It includes the aft end of the fueslage, the rudder, elevators, and stabilizers. The purpose of the empennage is to stabilize and control the aircraft.

Stabilizers. The stabilizing units of an aircraft consist of the vertical and horizontal surfaces located on the rear portion of the fuselage. The fixed vertical surface is called the vertical stabilizer or fin, and the horizontal surface is referred to as the horizontal stabilizer, which can either be fixed or movable. In recent years, the trend is toward the movable type of horizontal surfaces, such as *slabs* and *flying tails*. The *slab* (rotating stabilizer) has no control surfaces attached to it, while the *flying tail* type has the control surface attached to its trailing edge. Stability about the lateral axis of the aircraft is given by the horizontal stabilizer, which serves also as a base or anchor for attaching the elevators.

The vertical stabilizer or fin maintains directional stability of the aircraft about its vertical axis. The vertical stabilizer is also the base or anchor for attaching the rudder.

Construction Features. Structurally, empennages resemble wings, but are less complex and less integrated. They are usually full cantilever metal-covered airfoils. The spars are quite often nothing more than formed sheet metal channels. The rear spars are much heavier than the front spars—opposite to the arrangement used in wings—because the attachment of control surfaces cause the center of pressure to be far back on the airfoil, requiring strength farther aft. Ribs develop the cross-sectional shape. Fairings are used to streamline the angles formed between the stabilizers and the

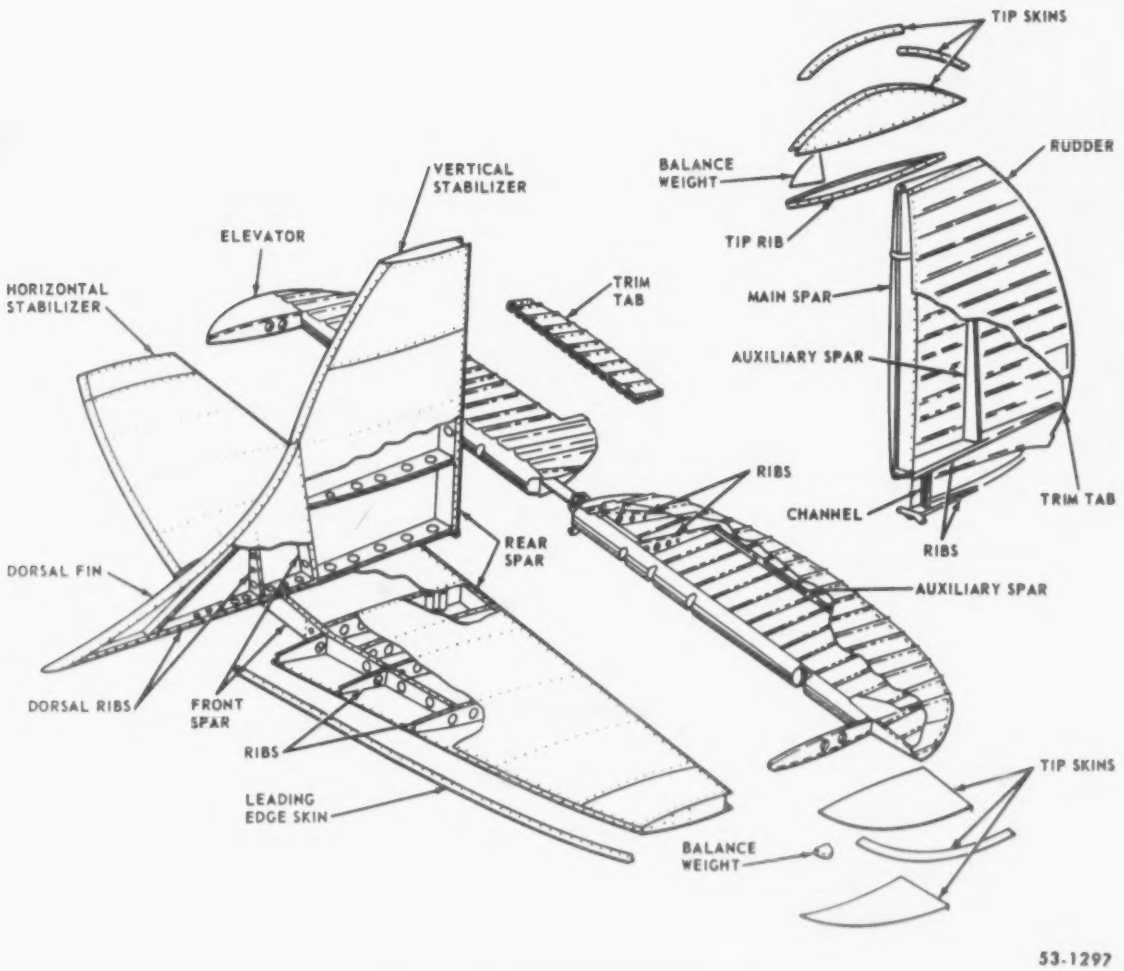

Figure 1-15. Empennage construction features.

fuselage. Figure 1-15 shows the individual structural parts of an empennage section.

Exercises (203):

1. What is the purpose of empennage section of an aircraft?

2. How does a *slab* differ from a *flying tail,* type of horizontal stabilizer?

3. What types of controls do the horizontal and vertical stabilizers exert?

4. Name the control surfaces normally found in empennage section of an aircraft.

5. How and why does the placement of the stronger spar in a stabilizer differ from that for the wing?

1-3. Control Surfaces

204. Cite the purpose and location of the control surfaces of an aircraft.

You are familiar with the simple processes involved in changing the direction of a moving vehicle such as

a truck, bus, or automobile. A mere turn of the front wheels does the job. In contrast to this directional change in one lateral plane of movement, an aircraft is unrestricted. An aircraft can move about all three axes—the lateral, the longitudinal, and the vertical—as illustrated in figure 1-16.

Flight control surfaces are hinged or movable surfaces which control the attitude or motion of an aircraft around the three axes during takeoff, flight, and landing. They consist of two major groups: the primary and the secondary.

Primary Group. The primary group of flight control surfaces consists of ailerons, elevators, and rudders. The ailerons are attached to the trailing edge of the wing sections of both the right and left wings of the aircraft. The elevators are attached to the trailing edge portion of the horizontal stabilizer. The rudder is attached to the trailing edge portion of the vertical stabilizer (see fig. 1-17).

All the various units of the primary group are similar in construction and vary only in size, shape, and in minor differences in attachments. In turn, the construction of these units is similar to that of the all-metal wing.

Primary control surfaces are usually made of an aluminum alloy structure built around a single spar member or torque tube. Ribs are fitted to the spar at the leading and trailing edges and are joined together with a metal strip. The ribs, in most cases, are formed from flat sheet stock. They are not solid, but contain punched holes which save weight. The trailing edges are made in various shapes and sizes.

The ailerons, rudder, and elevators are the surfaces by which maneuvers such as right and left bank, right and left turn, and nose-up and nose-down are made. Very few maneuvers or turns are executed by using only one of the three. The ailerons attached to the trailing edge of the outboard wing sections furnish control about the longitudinal axis for banking. The rudder gives direction control around the vertical axis. The elevators attached to the trailing edge of the horizontal stabilizer supply control about the horizontal axis for climbing or descending and turning by banking.

Secondary Group. The secondary group of control surfaces is composed of trim tabs, balance tabs, servo tabs, spoilers, slats, and flaps. Their purpose is to reduce the force required to actuate the primary group, to trim and balance the aircraft in flight, to reduce landing speed or shorten the length of the landing roll, and to change the speed of the aircraft in flight. They are attached to the trailing edges or recessed into the primary control surfaces. (See fig. 1-18.)

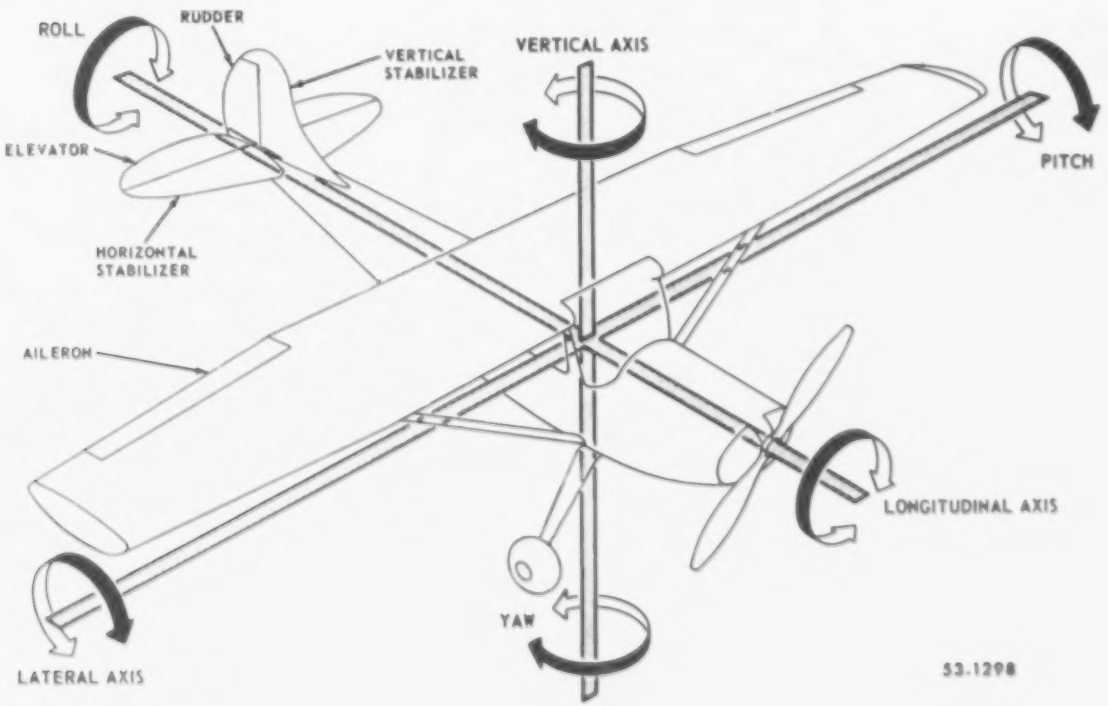

Figure 1-16. Axes and fundamental motions.

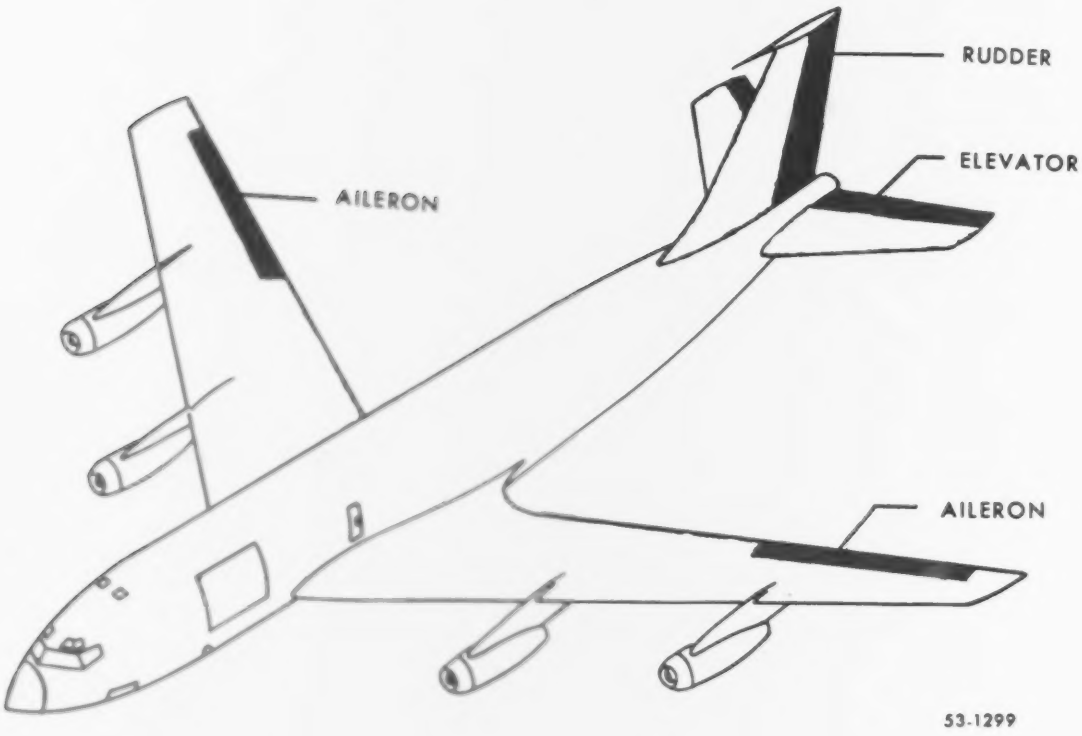

Figure 1-17. Primary control surfaces.

Trim tabs. Trim tabs are used to control the balance of the aircraft so that it will maintain level flight without pressure on the control stick or rudder pedals.

Balance tabs. Balance tabs are hinged to the primary control surfaces and are connected to the fixed structure by mechanical linkage to cause the tab to move in a direction opposite to that of the primary control surface. Balance tabs reduce the effort required by the pilot to move or to hold the control surface in any given position.

Servo tabs. Servo tabs are used primarily on large airfoils to aid the pilot in moving primary control surfaces. The tab control linkage is connected in such a manner that tab movement precedes the movement of the primary control surface. Air from the slipstream striking the tab moves the control surface in the desired direction.

Spoilers. A spoiler is a small, narrow, hinged, striplike flap arranged to project above the upper forward surface of a wing, ahead of the ailerons. Its purpose is to disturb the smooth airflow and increase the drag on a wing at the same time that the aileron on the same wing is turned upward. It makes an upturned aileron more effective.

Slats. Wing slats are airfoils attached to the leading edge of each wing panel. Slats reduce burbling and smooth out the flow of air over the airfoil. On most aircraft equipped with slats, aerodynamic forces acting upon the slats cause them to open or close automatically, depending on the airspeed and attitude of the aircraft. The automatic extension of the slats changes the airflow over the upper surface of the wing, increasing the lift and thus producing a lower stalling speed.

Flaps. Flaps increase lift and drag of the wing. They enable fast aircraft to reduce landing and takeoff speed. This shortens the landing roll in small or obstructed areas by permitting the gliding angle to be increased without increasing the gliding speed. As a rule, flaps are located on the surface of the rear portion of the wing from the aileron inward to the fuselage. On certain types of aircraft, sections of the leading edge of the wing are hinged so that they can also be used as flaps.

Exercises (204):

1. Where are the elevators located on an aircraft, and what purpose do they serve?

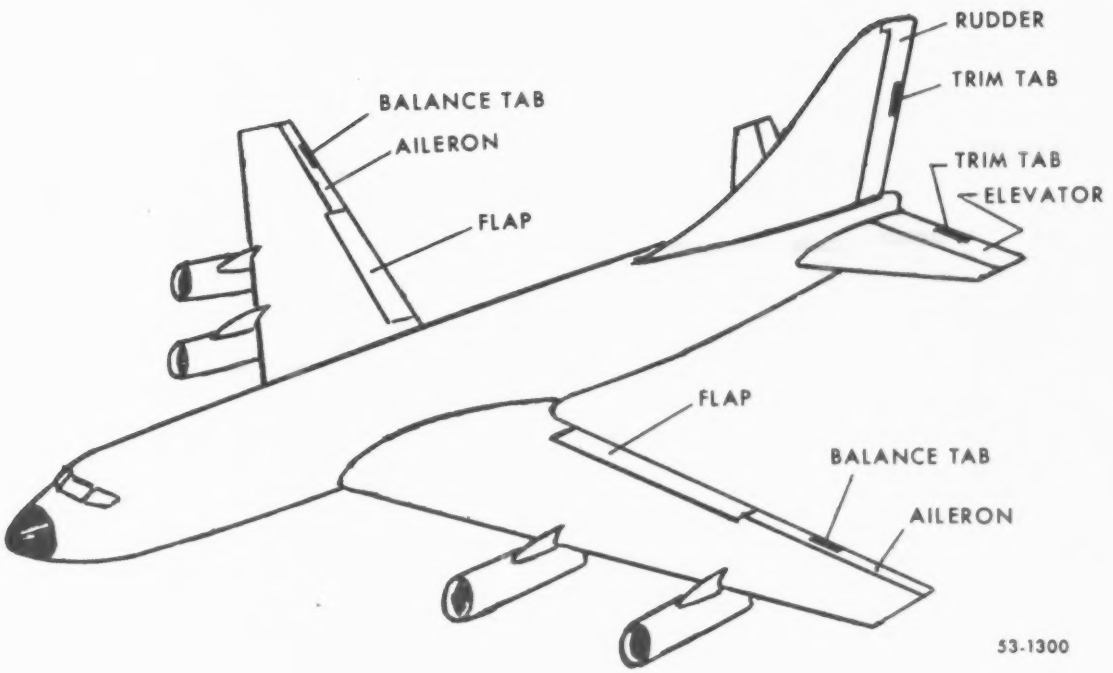

Figure 1-18. Secondary control surfaces.

2. Where is the rudder located on an aircraft and what is its purpose?

3. What primary control surface is normally located outboard of the wing flaps and what function does it serve?

4. What is the purpose of a spoiler?

5. What is the purpose of balance and servo tabs?

6. Where are trim tabs located?

7. Where are flaps located and what purpose do they serve?

8. Use figure 1-19 and write the name of the numbered control surfaces in the spaces provided below.

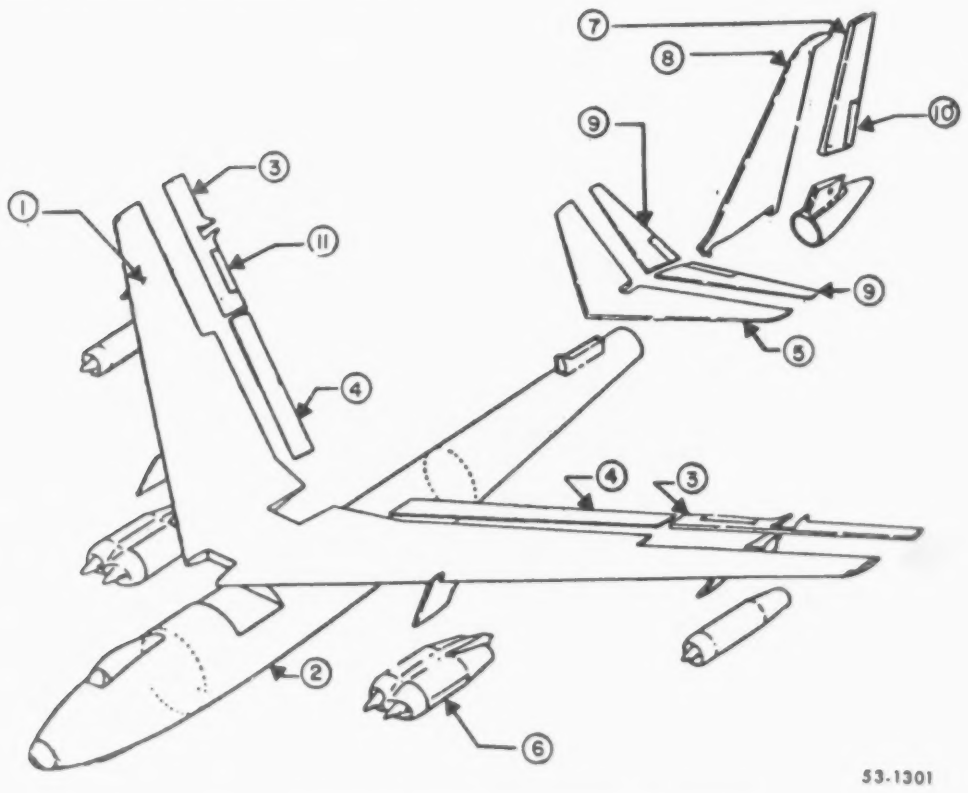

Figure 1-19. Numbered control surfaces (objective 204, exercise 8).

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

9. _____

10. _____

11. _____

CHAPTER 2

Aircraft Metals

IF A PART required exceptional strength to do a particular job, and it is *repaired* with a soft metal replacement, what could be the result? Picture yourself at a picnic. Out of the sky, the remains of an aircraft plunge to earth: 200,000 pounds of metal—and men, women, and children. Could this be the result of an aircraft being repaired by people who did not understand the many factors involved in metals and their properties? Unless *you* know what *you* are doing with metals, it *could* happen. This chapter contains information you need to identify and select the proper material for a specific repair. You will also learn the causes of corrosion, the different types of corrosion, and the areas of an aircraft to inspect for corrosion.

2-1. Characteristic Features of Metals

205. Differentiate between the properties of metals by matching defining terms with the correct metal properties.

Metal Properties. The properties of metals are of primary concern in selecting metals for aircraft construction and repairs. Some properties are necessary in aircraft maintenance, while others must be reduced or eliminated so as not to be a hindrance in aircraft maintenance. A study of all metal properties would be far beyond the scope of this course. Therefore, we will discuss those that you, as an airframe repairman, must consider in performing your work.

Hardness. Hardness is the ability of a metal to resist abrasion, penetration, cutting action, or permanent distortion. Hardness may be increased by working the metal and, in the case of steel and certain aluminum alloys, by heat-treatment and cold-working. Structural parts are often formed from metals in their soft state and then heat-treated to harden them so they will retain the finished shape. Hardness and strength are closely associated properties of metals. For special application, hardness may be measured in terms of resistance to scratching, wear, or impact.

Malleability. A metal which can be hammered, rolled, or pressed into various shapes without cracking, breaking, or other detrimental effects is said to be malleable. This property is necessary in sheet metal that is worked into curved shapes such as cowlings, fairings, and wing tips. Copper is an example of a malleable metal. Malleability refers to compression deformation as contrasted with ductility, which refers to tensile deformation.

Ductility. "Tensile deformation"? It means, loosely speaking, "stretching." Ductility is the property of a metal which permits it to be permanently drawn, bent, or twisted into various shapes without breaking. This property is essential for metals used in making wire and tubing. Ductile metals are greatly preferred for aircraft use because of their ease of forming and resistance to failure under shock loads. For this reason, aluminum alloys are used for cowl rings, fuselage and wing skin, and formed or extruded parts such as ribs, spars, and bulkheads. Chrome molybdenum steel is also easily formed into desired shapes. Ductility is usually expressed as percent elongation or percent reduction of area.

Elasticity. Elasticity is that property which enables a metal to return to its original shape when a force which causes the change of shape is removed. This property is extremely valuable because it would be highly undesirable to have a part permanently distorted after an applied load was removed. Each metal has a point known as the elastic limit, beyond which it cannot be loaded without causing permanent distortion. In aircraft construction, members and parts are so designed that the maximum loads to which they are subjected will never stress them beyond their elastic limits. This desirable property is exemplified in spring steel.

Toughness. A metal which possesses toughness will withstand tearing or shearing and may be stretched or otherwise deformed without breaking. Toughness is a desirable property in aircraft metals.

Density. Density is the weight of a unit volume of a material. In aircraft work, the actual weight of a material per cubic inch is preferred since this figure can be used in determining the weight of a part before actual manufacture. Density is an important consideration when choosing a material to be used in the design of a part in order to maintain the proper weight and balance of aircraft. For example, cast iron has a density of approximately one quarter of a pound per

cubic inch. Aluminum alloy 2024 has a density of approximately one-tenth of a pound per cubic inch. Density, or weight per unit volume, is helpful to you in identifying metals and alloys. Ferrous metals are usually heavy, while nonferrous metals are usually light.

Brittleness. Brittleness is the property of a metal which allows little bending or deformation without shattering. A brittle metal is apt to break or crack without change of shape. Because structural metals are often subjected to shock loads, brittleness is not a very desirable property. Cast iron or cast aluminum and very hard steel are brittle metals.

Melting point. The melting point of a metal is the temperature at which it changes from a solid to a liquid. Different metals have different melting points. The melting point is the temperature at which metals are fused in welding. Steel fuses at approximately 2500° F, and aluminum alloys at approximately 1100° F.

Coefficient of thermal conductivity. The coefficient of thermal conductivity is a number which tells how fast a material transfers heat from one part of it to another. Materials which have a high coefficient of thermal conductivity transfer heat quickly from one part to another. For example, copper has a high coefficient of thermal conductivity and requires a large volume of heat for welding. In contrast, stainless steel has a low coefficient of thermal conductivity and requires a lower volume of heat for welding.

Coefficient of thermal expansion. The coefficient of thermal expansion is a number which tells how much a material expands when heated. Material with a high coefficient of thermal expansion warps considerably when heated. For example, stainless steel warps more when heated than does low carbon steel.

Coefficient of electrical conductivity. The coefficient of electrical conductivity tells how well a material conducts electricity. Material having a high coefficient of electrical conductivity is a better conductor of electricity than one having a lower coefficient of conductivity. Copper and aluminum are especially good conductors of electricity. The electrical conductivity is usually expressed as a percent, with silver considered as 100-percent conductor.

Color. Color is that property of a material which causes it to reflect light of a certain wavelength. Different wavelengths produce different sensations on our visual senses. This is what gives us our impressions of color. Some materials, such as the penetrant used in fluorescent penetrant inspection, have the ability to lower the frequency of light normally not seen and to reflect it so that it is visible. Ultraviolet light, or "black light," is reflected as a whitish-green light by the material used in fluorescent penetrant inspection. Color is a big aid in identifying metals and alloys. Copper and its alloys are recognized by their reddish or bronze color; aluminum alloys are light gray, cadmium is white, etc.

Exercises (205):
Match the characteristic metal properties in column B with the correct terms in column A.

Column A	*Column B*
_____ 1. Hardness.	a. Ability to be hammered into various shapes without cracking.
_____ 2. Brittleness.	b. Resistance to penetration.
_____ 3. Ductility.	c. Resistance to tearing or shearing.
_____ 4. Toughness.	d. Returns to original shape after an applied load is removed.
_____ 5. Color.	e. Quality of twisting or drawing without breaking.
_____ 6. Density.	f. Weight per unit of volume.
_____ 7. Elasticity.	g. Breaks without a change of shape.
_____ 8. Malleability.	h. Transfers heat.
_____ 9. Thermal conductivity.	i. Increases in size when heated.
_____ 10. Thermal expansion.	j. Reflects light of a certain wavelength.

206. Define or explain characteristics of the factors considered in selecting a specific metal for use on an aircraft.

Selection Factors. The selection of proper materials is a primary consideration in the development of an airframe and in the proper maintenance and repair of aircraft. Keeping in mind the properties of metals, we can now consider the specific requirements which metals must meet to be suitable for aircraft purposes.

Strength/Weight Ratio. Airframes must be strong and yet as light as possible. There are very definite limits to the increase in weight allowable even for the purpose of increasing the strength. An aircraft so heavy that it could not support over a few hundred pounds of additional weight would be of little use.

The relation between the strength of a material and its weight per cubic inch is known as the strength/weight ratio. This ratio forms the basis for comparing the desirability of various materials for use in airframe construction and repair. Neither strength nor weight alone can be used as a means of true comparison. In some applications such as the skin of monocoque structures, thickness is more important than strength. In this instance, the material with the lightest weight for a given thickness or gage is best. Thickness or bulk is necessary to prevent buckling or damage caused by careless handling. All metal, in addition to having a good strength/weight ratio, must be thoroughly reliable, thus minimizing the possibility of dangerous and unexpected failures.

Corrosive properties. Corrosion is the eating away or pitting of the surface or the internal structure of metals. Because of the thin sections and the safety factors used in aircraft design and construction, it would be dangerous to select a material subject to severe corrosion. Corrosion is caused by the exposure of metals to fumes, water, acids, or moist air, especially moist salt air. Corrosion can be reduced or prevented by using better grades of base metals; by coating the surface with a thin coat of paint, tin, chromium, or cadmium; or by the electrochemical

process called anodizing. (We will discuss corrosion in more detail later in this chapter.)

Workability. Another significant factor to consider in maintenance and repair is the ability of a material to be formed, bent, or machined to required shapes. This *factor,* known as workability, depends on a number of the characteristics of metal we discussed previously.

Tensile strength. Tensile strength is the resistance that a substance offers to being pulled apart by a slowly applied load. Tensile strength increases or decreases as the hardness increases or decreases. The tensile strength of metal is usually stated in pounds per square inch of cross-sectional area.

Shear strength. Shear strength is the resistance to a cutting action similar to the cutting of a pair of scissors. A shear action is a force acting at an angle to the surface, a force which tends to cause the particles of a body to slide over each other. The shear strength of steel is approximately 60 percent of the tensile strength. Shear strength can be controlled in the same manner as tensile strength—that is, by varying the hardness of the metal.

Compressive strength. Compressive strength is the maximum compressive load (pressing or squeezing force) that a material can withstand.

Torsional strength. Torsional strength is the maximum twisting stress which a material can withstand.

Shock and fatigue resistance. Aircraft metals are subjected to both shock and fatigue (vibrational) stresses. If the fatigue limit is reached or exceeded, fatigue occurs in materials that are exposed to frequent reversals of loading or repeatedly applied loads. Repeated vibration or bending ultimately causes a minute crack to occur at the weakest point. As vibration or bending continues, the crack lengthens until complete failure of the part results. This is termed shock or fatigue failure. Resistance to this condition is known as shock or fatigue resistance. It is essential that materials used for critical parts be resistant to these stresses.

Ease of attachment. Joining metals structurally by welding, brazing, soldering, bonding or by such mechanical means as riveting or bolting, is a tremendous help in design and fabrication. When all other properties are equal, material that can be welded has the advantage.

Exercises (206):

1. Which selection factor is usually basic in selecting a particular metal for a given repair situation?

2. List three methods used to reduce or prevent corrosion in metal.

3. If the metal you have selected is very brittle, which selection factor was overlooked?

4. What is meant by shock and fatigue resistance?

5. Define the term "workability."

6. If the only concern in joining one piece of metal to another is strength, which method of attachment has the advantage?

7. What effect has cold-working on the tensile strength of a metal?

8. If you know the tensile strength of a piece of metal, could you figure out the shear strength? Explain your answer.

207. Describe, or identify from descriptions, the structural stresses encountered in metal structures.

Stress in Structural Members. Forces act on the aircraft whether it is on the ground or in flight. These forces cause pulling, pushing, or twisting within the various members of the aircraft structure. While the aircraft is on the ground, the weight of the wings, fuselage, engines, and empennage causes forces to act downward on the wing and stabilizer tips, along the spars and stringers, and on the bulkheads and formers. These forces are passed on from member to member, causing bending, twisting, pulling, compression, and shearing.

As the aircraft takes off, most of the forces in the fuselage continue to act in the same direction; but, because of the motion of the aircraft, they increase in intensity. However, the forces on the wingtips and the wing surfaces, reverse direction and instead of being downward forces of weight, they become upward forces of lift. First the forces of lift are exerted against the skin and stringers, then are passed on to the ribs, and finally are transmitted through the spars to be distributed through the fuselage to any deadweight items carried in the fuselage.

The wings bend upward at the end and may flutter slightly during flight. This wing bending cannot be

ignored by the manufacturer in the original design and construction, and cannot be ignored by the metal repairman during maintenance. It is quite surprising how an aircraft structure composed of structural members and skin rigidly riveted or bolted together, such as a wing, can bend or act so much like a large spring leaf.

The five types of stresses in an aircraft are tension, compression, shear, bending, and torsion (or twisting). Figure 2-1 illustrates examples of each type. The first three, tension, compression, and shear, are commonly called the basic stresses; the last two, bending and torsion are the combination stresses. The most important types of stresses from the standpoint of the airframe repairman are bending, torsion, compression, and shear. Let's examine them separately.

Tension. Tension (or tensile stress) is the force per unit area tending to stretch a structural member. In figure 2-2, Section A, note the condition of the metal strap after stretching. Drilling the bolt hole in the strap removed much of the material and reduced the cross-sectional area. Since the load is constant from one end of the strap to the other and the hole cannot carry any of the load, the stress in the reduced section is greatly increased (per unit area). The area on each side of the hole is carrying not only its normal share of the load but also that part of the load which should have been carried by the removed material. Obviously, if the load were increased until the strap failed, the break would occur in the material near the hole.

The strength of a member in tension is determined on the basis of its gross area (or total area), but calculations involving tension must take into consideration the net area of the member. Net area is defined as "the gross area minus that removed by drilling holes or by making other changes in the section." Placing rivets or bolts in holes makes no appreciable difference in added strength, as the rivets or bolts will not transfer tensional loads across holes in which they are inserted.

Compression. Compression (or compressive stress) is the force per unit area which tends to shorten (or compress) a structural member at any cross section. Under a compressive load, an undrilled member will be stronger than an identical member with holes drilled through it. However, if a plug of equivalent or stronger material is fitted tightly in a drilled member, it will transfer compressive loads across the hole and the member will carry approximately as large a load as if the hole were not there. Thus, for compressive loads, the gross or total area may be used in determining the stress in a member if all holes are tightly plugged with equivalent or stronger material.

Shear. Shear is the force per unit area which acts in such a way as to slide adjacent particles of material past each other. The term "shear" is used because it is a sideways stress of the type that is put on a piece of paper or a sheet of metal when it is cut with a pair of shears. Shear stress concerns you chiefly from the standpoint of rivet and bolt applications, particularly when attaching sheet stock, for if a rivet used in a shear application gives way, the rivet parts are pushed sideways.

Bending. Bending (or beam stress) is actually a combination of two forces acting upon a structural member at one or more points. In figure 2-2, Section B note

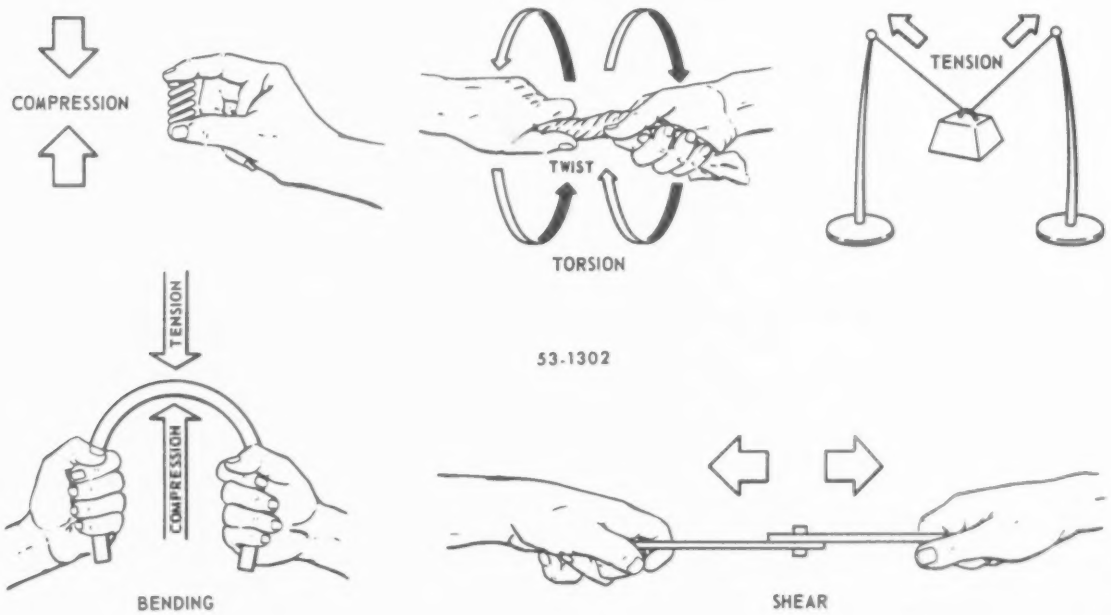

Figure 2-1. Examples of structural stresses.

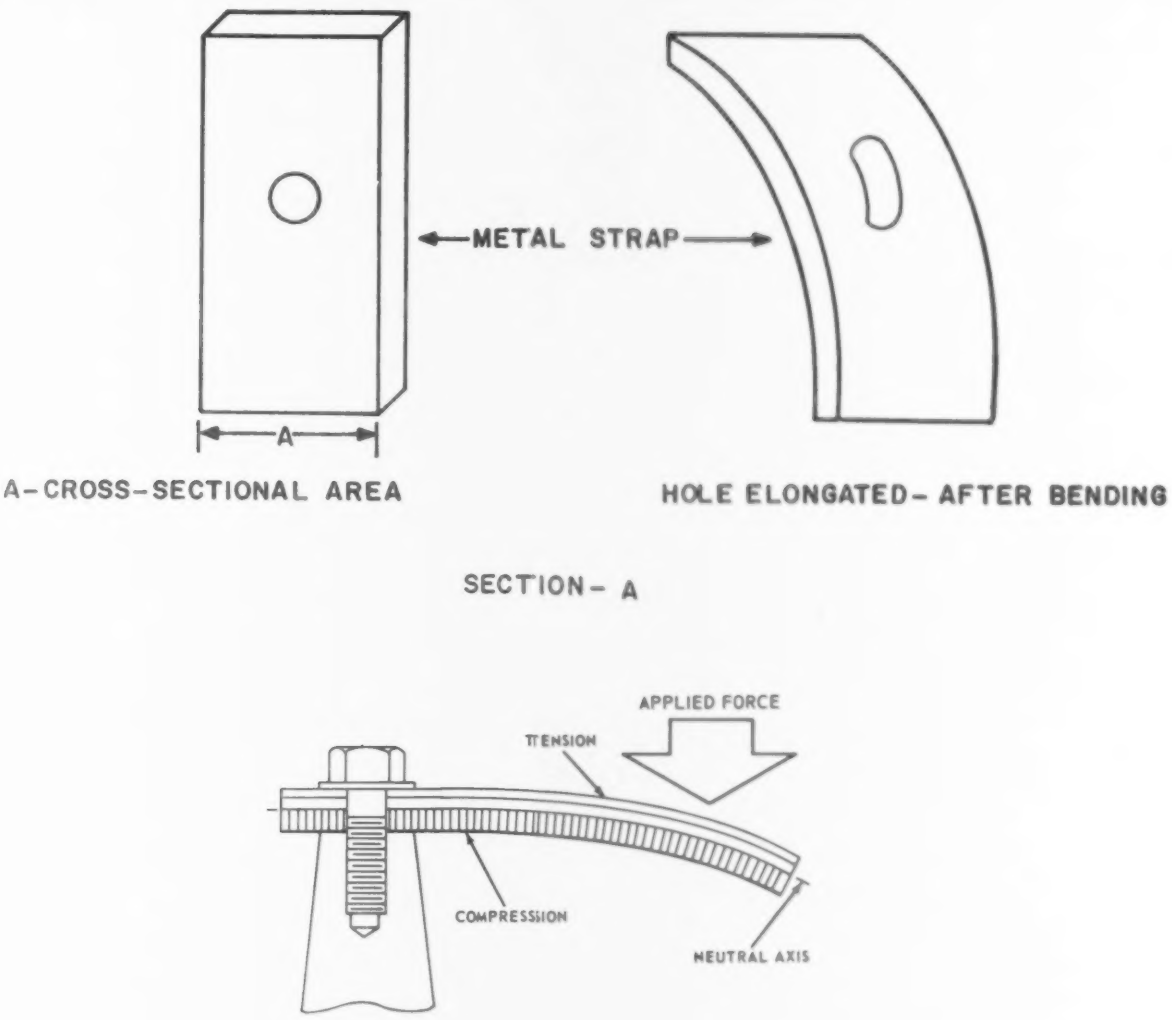

Figure 2-2. Tensile stress.

that the bending stress causes a tensile stress to act on the upper half of the metal stress and a compressive stress on the lower half. These stresses act oppositely on the two sides of the centerline of the member, which is called the neutral axis. Since these forces acting in opposite directions are next to each other at the neutral axis, the greatest shear stress occurs along this line, and no shear stress exists at the extreme upper or lower surfaces of the strap.

Torsion. Torsion (or twisting stress) is the force which tends to twist a structural member. The stresses arising from this action are shear stresses caused by the rotation of adjacent planes past each other around a common reference axis at right angles to these planes. This action may be illustrated by a rod fixed solidly at one end and twisted by a weight placed on a lever arm at the other, producing the equivalent of two equal and opposite forces acting on the rod at some distance from each other. A shearing action is set up all along the rod, with the centerline of the rod representing the neutral axis.

Exercises (207):

1. Define the term "tensile stress."

2. In which direction are the stresses of shear applied?

3. Where does the greatest stress occur when bending a piece of metal?

4. Which stress is the opposite of tension?

5. How do the stresses of bending and twisting differ?

6. Insertion of a tightly fitted plug in a drilled member permits which type of stress to be transferred across the plugged area?

2-2. Types of Aircraft Metals

208. Identify characteristics of aluminums used in aircraft construction, and associate specified effects with the characteristics which cause them.

Keeping in mind the terms we have discussed covering metal properties and selection factors, let us now turn our attention to various metals used in aircraft construction and repairs. We'll start with the one used the most—aluminum. We'll discuss why this metal is one of the most desirable of metals for general use on aircraft, methods used to identify aluminum, and the various types of aluminum.

Aluminum. Aluminum is one of the most abundant metals of the earth. About one-twelfth of the earth's crust contains aluminum—almost twice as much as the earth's iron content. Commercially pure aluminum is a white lustrous metal which stands second in the scale of malleability, sixth in ductility, and ranks high in its resistance to corrosion. Commercially pure aluminum has a tensile strength of about 13,000 pounds per square inch, but its strength can be almost doubled by rolling or other cold-working processes. By alloying with other metals and by using heat-treating processes, the tensile strength may be raised to as high as 100,000 pounds per square inch, or within the range of structural steel. Aluminum weighs far less than most metals. In the alloy form it weighs about 0.1 pound per cubic inch. This is about one-third the weight of iron at 0.28 pounds and copper at 0.32. It is slightly heavier than magnesium at 0.066 and somewhat lighter than titanium at 0.163 pounds.

Aluminum combined with various percentages of other metals (usually copper, manganese, magnesium, and chromium) forms alloys which are used in aircraft construction. The total percentage of alloying elements is seldom more than 6 or 7 percent in the wrought alloys. Aluminum alloys in which the principal alloying ingredients are either manganese, magnesium, chromium, or magnesium and silicon are not greatly affected by corrosive environments. Alloys in which substantial percentages of copper are used are more susceptible to corrosive action.

Aluminum melts at the comparatively low temperature of 1250° F. It is nonmagnetic and is an excellent conductor. But the outstanding characteristic of aluminum is its light weight. Aluminum is one of the most widely used metals in modern aircraft construction because of its high strength/weight ratio and its comparative ease of fabrication.

Most aluminum alloys, although strong, are easily worked because they are malleable and ductile. They may be rolled into sheets as thin as 0.0017 inch or drawn into wire 0.004 inch in diameter. Most aluminum alloy sheet stock used in aircraft construction ranges from 0.016 to 0.096 inch in thickness; however, sheet stock as thick as 0.356 inch is used on some of the larger aircraft.

One disadvantage of aluminum is the difficulty of making reliable solder joints. Oxidation of the surface of the heated metal prevents soft solder from adhering to the material; therefore, to produce good joints when working with aluminum alloys, a riveting process is used.

Types of Aluminum. The various types of aluminum are divided into two general classes: the casting aluminum alloys (those suitable for casting in sand, permanent mold, and die castings), and wrought alloys (those which may be shaped by rolling, drawing, or forging). Of these two, the wrought alloys are the most widely used in aircraft construction for stringers, bulkheads, skin, rivets, and extruded sections.

Cast. Cast aluminum alloys are divided into two groups. In one, the physical properties are determined by the elements added and the properties cannot be changed after the metal is cast. In the other, the elements added make it possible to heat-treat the castings to improve their mechanical properties and dimensional stability. High strength, together with good ductility, can be obtained by selection of suitable composition and by heat-treatment.

Aluminum alloy castings are produced by one of three basic methods: sand mold, permanent mold, or die casting. In casting aluminum, in most cases, different types of alloys must be used for different types of casting. Sand castings and die castings require different types of alloys than those used in permanent molds.

Sand and permanent mold castings are produced by pouring molten metal into a previously prepared mold, after which you allow the metal to solidify or freeze and then remove the part. If the mold is made of sand,

the part is a sand casting; if it is a metallic mold, usually cast iron, the part is a permanent mold casting. The metal flows into the mold under the force of gravity alone.

Die castings used in aircraft are usually aluminum or magnesium alloy. If weight is of primary importance, magnesium alloy is used since it is lighter than aluminum. Since aluminum alloy is a little stronger than most magnesium alloys, it is frequently specified. A die casting is produced by forcing molten metal under pressure into a metallic die and allowing it to solidify. The die is opened and the part removed. The basic difference between permanent mold casting and die casting is that in the permanent mold process the metal flows into the die under gravity flow only. In the die casting operation, the metal is forced under great pressure. Die castings are used where relatively large production of a given part is involved. Remember, any shape which can be forged can be cast. Keeping this background of castings in mind will help you understand the nature of the cast parts encountered in the process of repairing parts. Although aircraft use many cast parts, the type of aluminum you will most often encounter in your work as an airframe repairman is the wrought form.

Wrought. Most aluminum alloys used for wrought products contain less than 7 percent of alloying elements. By the regulation of the amount and type of elements added, the properties of aluminum can be enhanced and the working characteristics improved. Special compositions have been developed for particular fabrication such as forging and extrusion.

As with casting alloys, wrought alloys are produced in both heat-treatable and non-heat-treatable types. The principal wrought forms of alloyed aluminum are plate and sheet, foil, extruded shapes, tube, bar, and forging.

The terms "Alclad" and "Pureclad" are used to designate sheets that consist of an aluminum core coated with a layer of pure aluminum on one side or both sides. The thickness of the coating of pure aluminum depends on the thickness of the sheet. The nominal alclad thickness is 4 percent of the complete thickness for material under 0.063 of an inch; 2.5 percent for material in the range of 0.063-0.187 inch and 1.5 percent for material 0.188 inch and thicker.

Aluminum coated in this manner affords a dual protection for the core by (1) preventing contact with any corrosive agents and (2) preventing any attack from scratching or other abrasion. Do not be mislead by thinking that the pure aluminum coating completely prevents the core from being damaged. Careless handling and sloppy workmanship will damage a piece of clad aluminum beyond aircraft usability.

Exercises (208):

1. How can the tensile strength of commercially pure aluminum be increased?
2. In alloyed form, what is the density of aluminum as compared to iron, magnesium, and titanium?
3. Why is aluminum vital in aircraft construction?
4. What alloying element increases the possibility of corrosion in aluminum?
5. Why is soldering of aluminum joints difficult?
6. What determines the classification group of a *cast* aluminum product?
7. What is the basic difference between permanent mold casting and die casting?
8. What are the two types of wrought aluminum sheet stock?
9. The amount of alclad coating on wrought aluminum sheets depends on what?

209. Associate specified characteristics of aluminum and aluminum alloys with corresponding elements of the identification system.

The Air Force requires that all aluminum-base alloys be marked with specification numbers or code markings on approximately every square foot of material. If the material is not marked, the material must be identified and re-marked prior to use or storage. There are two ways that you, as an airframe repairman, have of identifying aluminum and aluminum alloys. The numbering or color coding system is one; chemical testing is the other.

Numbering System. Figure 2-3 illustrates a sample format of how the sheet, bar, and tube should be marked according to Federal specifications. Information such as material composition, temper condition, thickness, and Federal specifications are indicated by the markings found on the metal.

Material composition. The material composition of wrought aluminum and wrought aluminum alloy is designated by a four-digit index system. The system is divided into three distinct groups: 1xxx group, 2xxx through 8xxx group, and 9xxx group (which is unused at present).

In the 1xxx group, the first number indicates that the alloy contains at least 99 percent pure aluminum. The second digit of the group indicates controls over the impurities contained in the alloy. If the second number is zero, it indicates no special control over individual impurities. Otherwise, the second digit (1 through 9) in this group indicates the number of controls over individual impurities in the metal.

The last two digits of the 1xxx group are used to indicate the hundredths of 1 percent above the original 99 percent designated by the first digit. Thus, if the last two digits were 30, the alloy would contain 99 percent plus .30 percent of pure aluminum, or a total of 99.30 percent pure aluminum. Examples of alloys in this group are:

- 1100 99.00 percent pure aluminum with one control over individual impurities.
- 1130 99.30 percent pure aluminum with one control over individual impurities.
- 1275 99.75 percent pure aluminum with two controls over individual impurities.

In the 2xxx through 8xxx groups, the first digit indicates the major alloying element used in the formation of the alloy as follows:

- 2xxx—copper.
- 3xxx—manganese.
- 4xxx—silicon.
- 5xxx—magnesium.
- 6xxx—magnesium and silicon.
- 7xxx—zinc.
- 8xxx—other elements.

In the 2xxx through 8xxx alloy groups, the second digit in the alloy designation indicated alloy modifications. If the second digit is zero, it indicates the original alloy. The digits 1 through 9 indicate alloy modifications.

In the 2xxx through 8xxx alloy groups, the last two of the four digits in the designation serve only to identify the different alloys in the group. Generally, these digits are the same as those formerly used to designate the same alloy. Thus, 2014 was formerly 14S, 3003 was 3S, and 7075 was 75S. For new alloys, the last two digits are assigned consecutively beginning with xx01. Experimental alloys are also designated by this system except that the 4 digit number is prefixed by an "X."

Temper designator. Temper refers to the hardness of a metal. The temper of aluminum alloys is produced

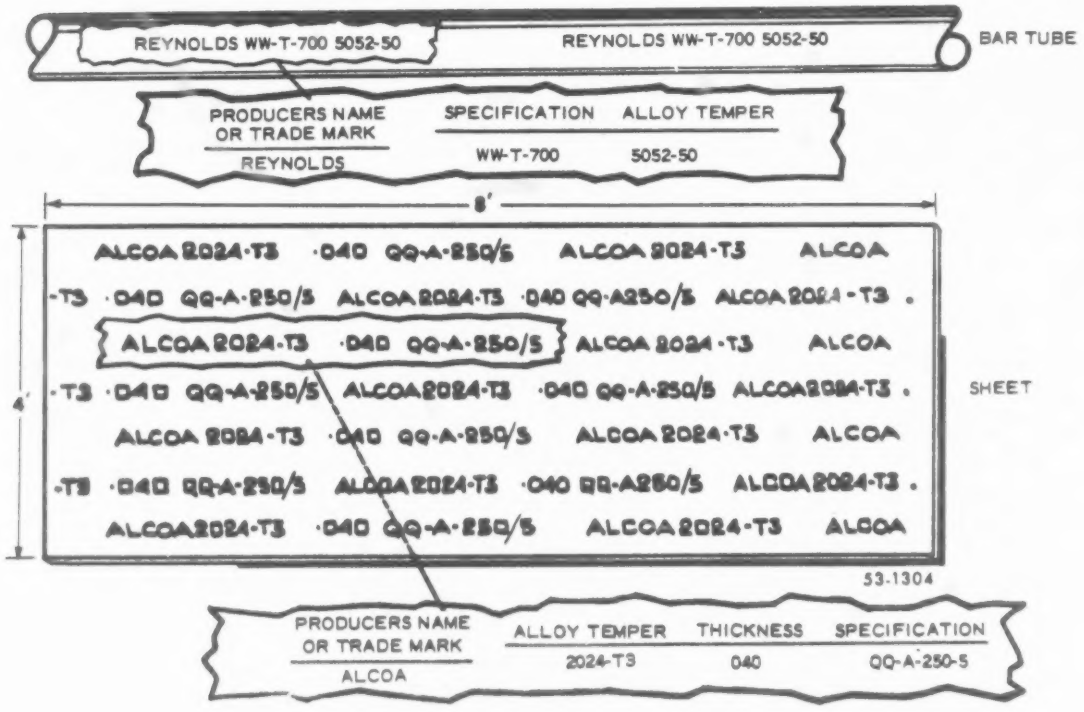

Figure 2-3. Markings for aluminum alloys.

essentially by one of three methods. These methods are cold-working (strain-hardening), heat-treatment, and a combination of the two. The temper designation follows the alloy designation and is separated from it by a dash; i.e., 7075-T6, 2024-T4, etc. The temper designation consists of a letter indicating the basic temper which may be more specifically defined by the addition of one or more digits. The temper designators for the heat-treatable aluminum alloys such as 2014, 2017, 2024, 6061, 7075 and 7178 are as follows:

- -F As fabricated.
- -O Annealed.
- -W Solution heat-treated unstable temper.
- -T Treated to produce stable tempers other than -F, -O, or -H.
  - -T2 Annealed (cast products only).
  - -T3 Solution heat-treated and then cold-worked.
  - -T4 Solution heat-treated.
  - -T5 Artificially aged only.
  - -T6 Solution heat-treated and then artificially aged.
  - -T7 Solution heat-treated and then stabilized.
  - -T8 Solution heat-treated, cold-worked, and then artificially aged.
  - -T9 Solution heat-treated, artificially aged, and then cold-worked.
  - -T10 Artificially aged and then cold-worked.

When a number is added to the above designators, it denotes a modification of a standard temper. An example of this is -T36. The numeral "6" indicates a different amount of cold-work than used in -T3.

The temper designators for non-heat-treatable aluminum alloys such as 1100, 3003, 3004, 5050, and 5052 are as follows:

- -F As fabricated.
- -O Annealed.
- -H Strain-hardened.
  - -H1 (plus one or more digits) Strain-hardened only.
  - -H2 (plus one or more digits) Strain-hardened and partially annealed.
  - -H3 (plus one or more digits) Strain-hardened and stabilized.

If a second number is added to the above strain-hardened indicators, this indicates the degree of strain hardening (actual temper).

Examples:

H12 = ¼ hard
H14 = ½ hard
H16 = ¾ hard
H18 = full hard

Cast aluminum alloys are represented by groups of numbers and letters which are divided into two parts separated by a hyphen. The first part of the identification symbol represents the alloying number, as in the case of wrought alloys, while the second part represents the temper condition.

In the casting alloy 214, the addition of zinc to increase the pouring qualities is designated by the letter A in front of the alloying number, thus the designation A214. When castings have been heat-treated, the heat-treatment is indicated by the letter T following the alloying number. An example of this is the sand casting alloy 355 which has several different compositions and tempers, and is designated by 355-T6, 355-T5, and A355-T51.

Thickness. Another important bit of information printed on the sheet is the thickness of the metal. This thickness (sometimes called gage) is measured in thousandths of an inch and is printed as a decimal fraction of an inch. (*Example:* .040, .063, or .250.)

Specifications. Federal specification numbers refer to the document which establishes how much materials are incorporated into the production of a particular alloy desired by the Government.

Color Coding. The identification of small sizes of bars, tubing, and wire by specification number is impracticable, and a color code marking, consisting of painted stripes, has been established. There are ten colors used in this identification marking system to represent numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, and 0. These ten colors are also used to represent letters F, H, O, T, W, A, B, C, D, and S. Figure 2-4 shows the correlation of colors to both numerals and letters. A combination of these colors, representing a combination of numbers and letters, is used to mark material to denote its material designation. For example, aluminum alloy with material designation 2218-T6 is marked green, (space), green, blue, white, (space), yellow, and red. Figure 2-5 illustrates the color coding sequence for 2218-T6.

Chemical. If for any reason the identification marking is not on the material, it is possible to separate the heat-treatable alloys from the non-heat-treatable by immersing a sample of the material in a 10 percent solution of caustic soda (sodium hydroxide). The heat-treatable alloys turn black due to the copper content of the alloy, whereas the others remain bright. In the case of clad material, the surface remains bright but there is a dark area in the middle when viewed from the edge.

To distinguish 7075 aluminum alloy from 2024 aluminum alloy, remove any protective finish from the spot to be tested. Do not remove the alclad surface. Place a drop of 10 percent cadmium chloride on the cleaned area. The following results will take place depending on the alloy:

- 7075 Alclad — A dark gray deposit will form within 2 minutes.
- 7075 Bare — A dark gray deposit will form within a few seconds.
- 2024 — No deposit will form in the time specified for 7075. A faint deposit will form after 15 to 20 minutes.

The 10 percent cadmium chloride solution is quite stable and may be kept in stoppered containers indefinitely. The effectiveness of the solution can be

Color	Equivalent no.	Equivalent letter
Black	0	S
Blue	1	F
Green	2	H
Olive drab	3	O
Yellow	4	T
Orange	5	W
Red	6	A
Maroon	7	B
White	8	C
Gray	9	D

53-1306

Figure 2-4. Color coding—aluminum alloys.

tested at any time by applying a drop to a piece of 7075 and noting the formation time for the gray deposit.

Exercises (209):

1. What does the first number of the four-digit index system used for aluminum indicate?
2. Which process of tempering aluminum is indicated by the temper designator H?
3. What processes are used to develop -T6 aluminum alloys?
4. If a second number is added to the temper designator -H1, what does this tell you?
5. How is the thickness of aluminum indicated on wrought materials?
6. What is the color coding sequence for 7178-T3?

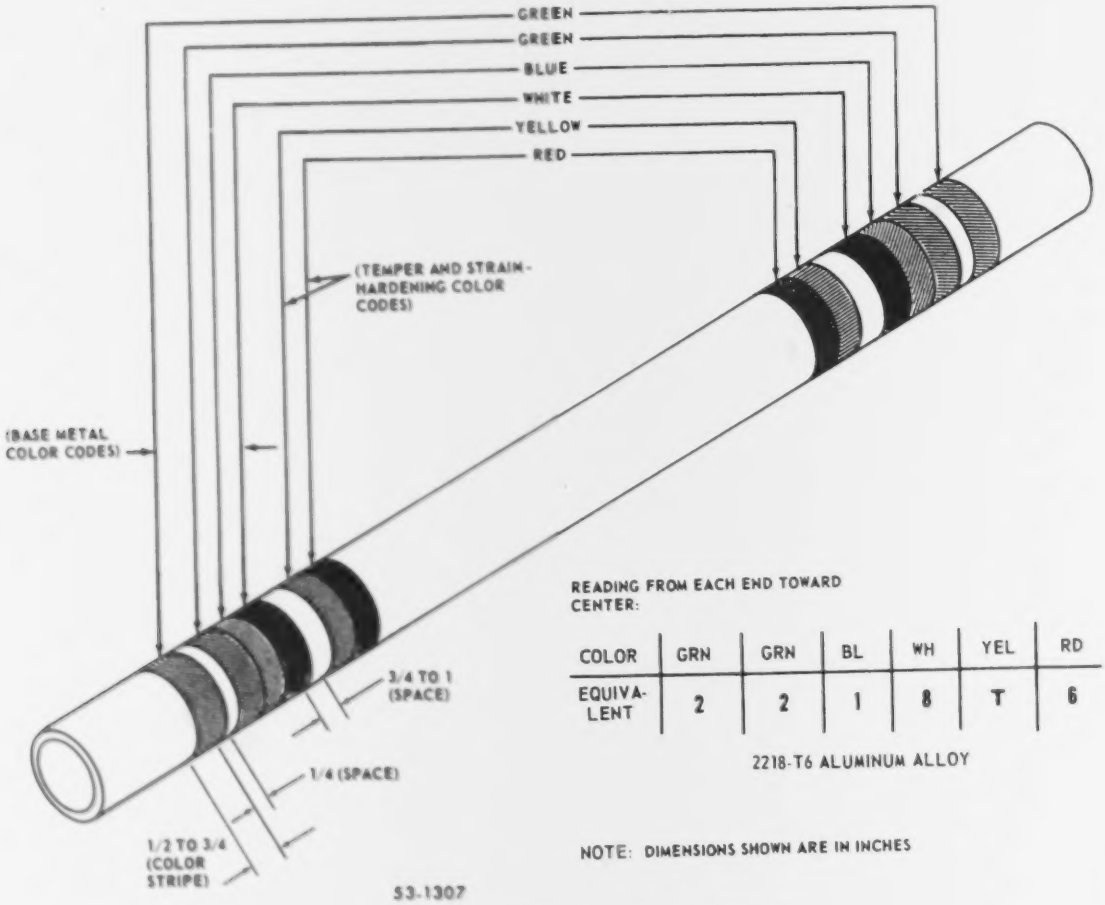
GREEN
GREEN
BLUE
WHITE
YELLOW
RED
(TEMPER AND STRAIN-HARDENING COLOR CODES)
(BASE METAL COLOR CODES)
3/4 TO 1 (SPACE)
1/4 (SPACE)
1/2 TO 3/4 (COLOR STRIPE)
53-1307
READING FROM EACH END TOWARD CENTER:
COLOR | GRN | GRN | BL | WH | YEL | RD
EQUIVALENT | 2 | 2 | 1 | 8 | T | 6
2218-T6 ALUMINUM ALLOY
NOTE: DIMENSIONS SHOWN ARE IN INCHES

Figure 2-5. Example of color coding—aluminum alloys.

7. A chemical solution of sodium hydroxide is used on aluminum and aluminum alloys to identify (differentiate) what?

8. Cadmium chloride is used on aluminum alloys for what purpose?

9. A uniform numbering system is used for identifying aluminum and aluminum alloys. Using the number 5052-0 .063 QQ-A-250/8 as an example, write in (below) the kind of information provided by each part of the identifier.

(1) 5050 _____

(2) 0 _____

(3) .063 _____

(4) QQ-A-250/8 _____

10. What do the Federal specification numbers indicate?

210. Identify characteristics and uses of heat-treatable and non-heat-treatable aluminum alloys.

Heat-Treatable Alloys. Greater strength is obtainable in the heat-treatable alloys. Therefore, they are used for structural purposes in aircraft. Let's consider nine heat-treatable aluminum alloys commonly used in aircraft construction and typical uses for each kind.

Alloy 2014. This alloy is used for extrusions and forgings. It is similar to 2017 and 2024 in that it contains a high percentage of copper. It is used where more strength is required than that obtainable from 2017 and 2024..

Alloy 2017. Rivets, stressed-skin covering, and other structural members are made from this alloy.

Alloy 2024. This alloy is used for heat-treated parts, airfoil covering, and fittings. It is stronger than alloy 2017 and may be used when alloy 2017 is specified.

Alloy 2025. Most propeller blades are made from this alloy.

Alloys 5053, 6061, 6062, and 6063. These alloys are used for oxygen and hydraulic lines and in some applications as extrusions and wrought sheets. Alloy 6061 offers the best weldability of the heat-treatable alloys.

Alloy 7075. This alloy differs from the other high-strength aluminum alloys in that zinc (instead of copper) is the main alloying element. Alloy 7075 is used where extra high strength and hardness is required. Alloy 7075 contains a small amount of chromium as a stabilizing agent.

Non-Heat-Treatable Alloys. These alloys do not respond to any heat-treatment other than by a softening annealing effect. They may be hardened only by cold-working. Three non-heat-treatable alloys are commonly used today.

Alloy 1100. Where strength is not an important factor but weight, economy, and corrosion resistance are desirable, alloy 1100 is used. It is not used for structural aircraft parts. It is used for the fabrication and repair of fuel and oil tanks, fairings, and wingtips.

Alloy 3003. This alloy is similar to alloy 1100 and is generally used for the same purposes. It contains a small percentage of manganese and is stronger and harder than alloy 1100, but retains enough workability so that it is usually preferred over alloy 1100 in most applications.

Alloy 5052. Alloy 5052 is used for fuel lines, hydraulic lines, fuel tanks, and wingtips. Substantially higher strength without too much sacrifice of workability can be obtained in alloy 5052. It is, therefore, preferred over 1100 and 3003 in any applications.

Exercises (210):

1. Where do you find heat-treatable aluminum alloy on an aircraft?

2. Which aluminum alloy is used in the fabrication of most aircraft rivets?

3. If you had to replace aluminum alloy 2024, with another copper alloyed aluminum alloy, which alloy would you select?

4. Which heat-treatable aluminum offers the best results when welding?

5. How does alloy 7075 differ from the other high-strength aluminum alloys?

6. Why must non-heat-treatable aluminum alloys be cold-worked to increase their strength?

7. Of all the non-heat-treatable aluminum alloys, which has the highest strength?

211. State the characteristic features of titanium.

Titanium. Titanium, in a mineral state, is the fourth most abundant structural metal in the earth's crust. Processing it into a metal, however, is a complex and expensive process. It is a light, strong, corrosion-resistant, ductile metal. Titanium is a very active metal, and readily combines with carbon, oxygen, and nitrogen. The most pronounced effects are obtained from oxygen and nitrogen. For this reason any heating process must be performed in a closely controlled atmosphere to prevent the absorption of oxygen and nitrogen to a point of brittleness.

Titanium and its alloys are used chiefly for parts which require good corrosion resistance, moderate strength up to 600° F (315° C) and light weight. Due to its high cost, titanium is used only where outstanding results will be obtained by its use.

Strength/weight ratio. Althoug titanium is about 43 percent lighter than steel, it can often (on a strength/weight basis) be equated to steels having yield strength levels approximating 300 kilograms per square inch. Compared to aluminum, titanium alloys (60 percent heavier than aluminum) are much stronger, and show a higher fatigue resistance and greater hardness.

Corrision resistance. The corrosion resistance of titanium is excellent, due mainly to the tenacity of its natural oxide surface. This thin, stable, continuous film of oxide or absorbed oxygen forms readily at low temperatures. With increasing temperatures, the thickness and permeability of the protective oxide film increases to the point where oxygen diffuses into the metal and produces brittleness and corrosion. This tendency limits the use of titanium where high temperatures are encountered.

In general, titanium is equal to, or better than, most metals in resistance to direct chemical corrosion by a wide variety of chemicals and is generally resistant to stress corrosion, erosion corrosion, galvanic corrision, and oxidation.

Thermal conductivity. Titanium is a metal between aluminum and stainless steel in terms of modulus of elasticity, density, and strength at high temperatures. It has a melting point of 2730° to 3155° F, low thermal conductivity, and low coefficient of expansion. Titanium is nonmagnetic, and its electrical resistance characteristics are similar to those of corrosion-resistant steel.

Crystal Structure. In the solid state each metal has a prevalent and characteristic formation of its atoms (crystal structure). The arrangement of this structure has definite influence on the characteristics of the metal. Alloying can alter structures or produce a combination of structures.

The A-B-C classification of titanium alloys was established to provide a convenient and simple means of describing all titanium alloys. Titanium alloys possess three basic types of crystal structure: A-(alpha), B-(beta), and C-(combined alpha and beta). Each type has its own characteristics.

Alpha alloy. Alpha alloys cannot be heat-treated. Most of the alpha alloys contain some beta alloying elements, but the composition of these alloys is balanced by high aluminum content, so the alloys are essentially alpha. The alpha alloys have two main attributes: weldability (resulting from the microstructure), and retention of strength at high temperatures (resulting from the presence of aluminum). Alloying elements in solution strengthen the alpha alloys. Aluminum is the most effective strengthener of alpha alloys; especially important is that its effect persists even at high temperatures.

Beta alloy. Beta alloys have good bendability, excellent ductility, are strong both hot and cold, but vulnerable to contamination. They are the most widely used big consumers of strategic alloys. The high percentage of beta-stabilizing elements chromium, columbian, copper, iron, manganese, molybdenum, tantalum, and vanadium incorporated in the alloying of titanium make the alloy weldable; and more important, beta alloys can be strengthened by heat-treatment because their microstructure can be manipulated by controlled heating, quenching, and aging cycles.

Alpha-beta alloy. Combined alpha and beta alloy is used for compromise performances. It is strong when cold or warm, but weak when hot. It has good bondability, moderate contamination resistance, and excellent forgeability.

Exercises (211):

1. Why is titanium used in aircraft construction?

2. Since titanium gives excellent results when used for aircraft parts, why is it not used more widely than it is?

3. What happens to titanium if it is exposed to high temperatures?

4. Why is titanium rated high in corrosion resistance?

5. Which of the classification of titanium alloys *cannot* be heat-treated?

6. What effect does the alloying of aluminum have on titanium?

7. Which of the classifications of titanium is highly vulnerable to contamination?

212. Describe the methods used to identify titanium.

To date, there is no single accepted system for the designation or classification of titanium and its alloys such as there is for aluminum. Several systems have been tried; none has won unanimous acceptance. They were based on one or more of three charcteristics: chemical composition, alloy phase, and strength level. Today, much the same situation prevails.

Titanium and its alloys are referred to as commercial pure (an alpha form), or as an alpha, alpha-beta, or all-beta alloy. The basic alloying elements are given, such as Ti-6Al-4V (for titanium alloyed with 6 percent aluminum and 4 percent vanadium.) Another commercial practice is to prefix the approximate yield strength of the alloy (in thousands of pounds per square inch) with the company initials, such as XYC-130. Digital systems are employed to designate certain alloys. The airframe repairman must be careful when specifying titanium alloys to insure that he gets the correct alloy composition, and special properties. Information on the designations and identifications of titanium can be found in Technical Order 1-1A-9, *Aerospace Metals—General Data and Usage Factors.*

Metal Marking. Sheet titanium is marked in much the same way as aluminum alloy sheet (see fig. 2-6). The metal is marked with a continuous ink roll marker. The marking includes:

- The brand name or trade name.
- Type of titanium.
  Type I (commercially pure).
  Type II (alpha phase).
  Type III (alpha-beta phase).
  Type IV (beta phase).
- Composition (A through F denoting actual composition of the material).
- Thickness (in thousandths of an inch).
- Previous heat-treatment.
- Specification number.

Testing. Titanium is similar in appearance to stainless steel. One quick method used to identify titanium is the spark test. Titanium gives off a brilliant white trace ending in a brilliant white burst when touched to the grinding wheel. Identification can be made by moistening the titanium and drawing a line on a piece of glass. This will leave a dark line similar in appearance to a pencil mark.

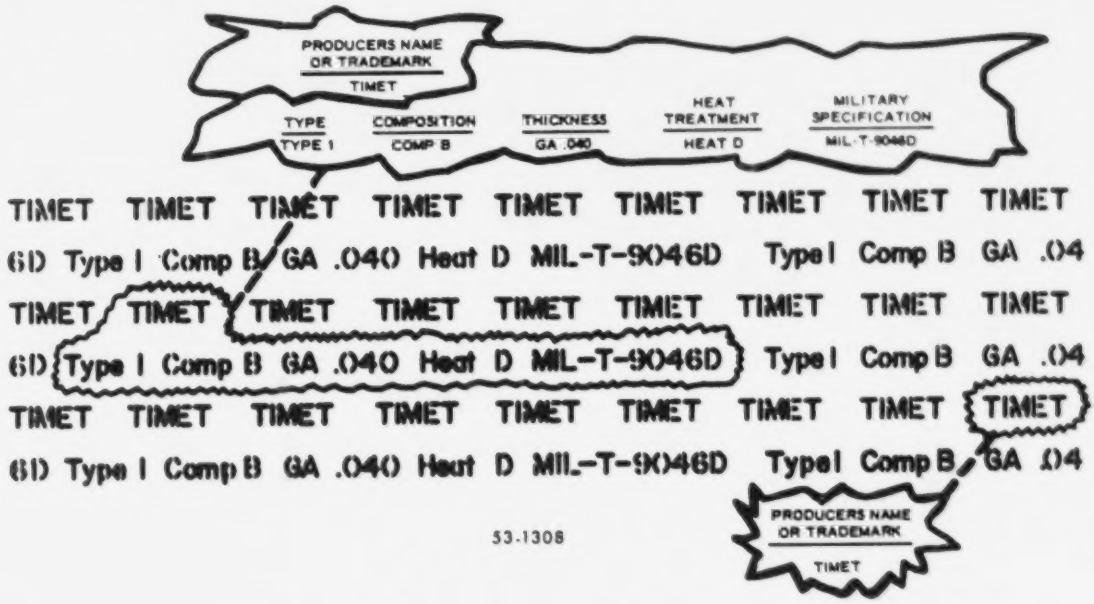
PRODUCERS NAME OR TRADEMARK
TIMET
TYPE
TYPE I
COMPOSITION
COMP B
THICKNESS
GA .040
HEAT TREATMENT
HEAT D
MILITARY SPECIFICATION
MIL-T-9046D
TIMET TIMET TIMET TIMET TIMET TIMET TIMET TIMET TIMET
6D Type I Comp B GA .040 Heat D MIL-T-9046D Type I Comp B GA .04
TIMET TIMET TIMET TIMET TIMET TIMET TIMET TIMET TIMET
6D Type I Comp B GA .040 Heat D MIL-T-9046D Type I Comp B GA .04
TIMET TIMET TIMET TIMET TIMET TIMET TIMET TIMET TIMET
6D Type I Comp B GA .040 Heat D MIL-T-9046D Type I Comp B GA .04
PRODUCERS NAME OR TRADEMARK
TIMET
53-1308

Figure 2-6. Markings for titanium.

Exercises (212):

1. What technical order contains information on the designations and identifications of titanium?

2. What tests are used to identify titanium from stainless steel?

3. How is the thickness of titanium indicated on titanium sheets?

4. If the designation Ti-4A1-6V appears on wrought titanium, what do the numbers 4 and 6 indicate?

213. Identify the characteristic features of magnesium and magnesium alloys.

Magnesium. Magnesium, the world's lightest structural metal, is a silvery white material weighing only about two-thirds as much as aluminum. Magnesium is probably more widely distributed in nature than any other metal. Magnesium, when alloyed with a small amount of such other metals as aluminum, manganese, zirconium, zinc, rare earth metals, and thorium, yields alloys with excellent properties and high ratios of strength to weight.

A versatile metal, magnesium can be shaped and worked by practically all methods known to the metal worker. It can be cast by sand, die, and permanent mold methods, extruded into an endless variety of shapes and rolled into sheets and plates. Magnesium can be joined by arc, electric resistance, and gas welding methods, and by adhesive bonding, riveting, bolting, and brazing. Let's examine some of the physical and chemical properties of magnesium.

Physical properties. Magnesium, in its pure state, has a specific gravity of 1.74, weighing .063 pound per cubic inch. It is nonmagnetic and relatively high in electrical conductivity. It exhibits good dimensional stability. The coefficient of thermal expansion of magnesium alloys is critical in the temperature range from 70° to 212° F. In applications where magnesium is rigidly connected to other metals and is subject to variation in temperature, consideration must be given to this relatively high coefficient. Magnesium has good fatigue properties.

Chemical properties. Bare magnesium is resistant to attack by alkalis, chromic and hydrofluoric acids, and many organic chemicals, including hydrocarbons, aldehydes, alcohols, phenols, amines, esters, and most oils. It is susceptible to attack by salts and galvanic corrosion from contact with dissimilar metals and other materials. Adequate protection of the metal against unfavorable conditions can be maintained generally by using proper surface finish and assembly protection.

Types of Magnesium. Magnesium is available in various compositions including the commercially pure (99.8 percent minimum), alloys for casting, and alloys for the manufacture of wrought products. Ordinarily, the compositions used for casting are different from those employed for rolling, forging, and other working. Substantially, pure magnesium finds practically no use in aircraft design or for stressed parts.

Casting alloys. There are four groups of magnesium casting alloys. The first group is based on the Mg-Al binary (2 part) system and is subdivided into those alloys containing zinc and manganese. The second group is based primarily on the Mg-Zn binary system with zirconium additions. These two groups are valuable for their structural behavior at normal or slightly high temperatures of less than 300° F. The third group is based on the magnesium-rare earth-metal binary alloys, and the fourth on the Mg-Th binary system. The last two groups have been specifically designed for strength at temperatures of 500° to 800° F. Although some of these casting alloys have outstanding normal temperature properties, they are not competitive with alloys of the first two groups because of the higher cost of the alloying elements.

Wrought alloys. There are many types of wrought products such as rolled sheet or plate, extrusion, and forgings. These worked forms have the advantage of lower cost, higher strengths and ductilities, and have greater versatility of mechanical properties than cast forms. Magnesium is well adapted to all three working processes, expecially extrusion.

Certain magnesium alloys, in cast and wrought forms, can be heat-treated to improve their properties. Magnesium alloys have been developed for high temperature service. Since these alloys contain thorium, a low level radioactive material, they must be handled, stored, and disposed of in accordance with TO 00-110N-4.

Exercises (213):

1. Why is the density of magnesium important to its use as a structural metal?

2. Magnesium is very susceptible to what type of corrosion?

3. What groups of cast magnesium alloys are used in areas where temperatures exceed 650° F?

4. What metal working processes can be used with magnesium, and to which one is it especially well adapted?

5. Why are you most likely to find two particular groups of cast magnesium alloys being used in aircraft construction?

6. Why do magnesium alloys containing thorium require special handling?

214. Describe the methods used to identify magnesium alloys, and analyze a given magnesium alloy designation.

Metal Markings. Shipping containers are marked as indicated in the individual metal's specification. In general, each container has the following designations: alloy, specification, size or form, quantity, contractor's name, and other pertinent information as required by the specification. The different forms of the material are marked as indicated:

a. Castings are identified with the pattern or part number, by the use of raised numerals. They may be stamped with symbols to indicate heat-treatment and aging.

b. Forgings are identified with the part number by the use of raised numerals.

c. Extrusions are marked with the manufacturer's trademark and specification along the full length at intervals of 2 feet or less, with paint, marking fluid, or other means.

d. Sheet is marked with the specification, manufacturer's trademark, thickness, and composition in rows of recurring symbols from edge to edge, with a suitable marking fluid.

Standard Alloy Designation System. Magnesium alloys are identified by a standard system of alloy designation, adopted in 1948 by the American Society for Testing Metals (ASTM). As an example of how the system works, consider the magnesium alloy AZ92A-T4. The first part of the designation (AZ) signifies that aluminum and zinc are the two principal alloying elements. The second part of the designation (92) means aluminum and zinc are present in rounded-off percentages of 9 and 2 percent. The third part (A) indicates that this is the first alloy standardized with 9 percent aluminum and 2 percent zinc as the principal alloys. The fourth part (-T4) means that the alloy is in the solution heat-treated condition. The temper designators are the same as those used for aluminum, with the addition of an "as cast" (-AC) indicator. Figure 2-7 explains the individual parts of the magnesium alloy designators and their meaning and shows what kind of symbols each part may contain.

Identification Testing. If the identification markings have been obliterated, you can distinguish magnesium from aluminum by means of a spot test. A one-half of one percent solution of silver nitrate in contact with a magnesium surface causes the metal to turn black, in sharp contrast to an aluminum surface which does not react to the solution. To make a spot test on an unknown alloy, first clean the surface of the metal with a file. Make sure you clean the spot deep enough to remove any paint or other surface coating to expose the base metal. Place a drop of silver nitrate solution on the cleaned surface. If the surface turns black, then the metal is magnesium; but if no reaction occurs, it is probably aluminum. This test merely identifies the metal as magnesium base alloy; the exact identity of the various compositions can be determined only by a chemical analysis. (Cadmium and zinc also react with silver nitrate, but since these metals would likely be present only as thin coatings, the deep filing would remove them.)

Another test to determine whether a metal is aluminum alloy or magnesium alloy is the flame test. Cut a small chip from the metal and heat it with an acetylene torch. Aluminum alloy melts and forms a ball of molten metal; magnesium alloy ignites, burns with a brilliant white light, gives off white smoke, and leaves a white ash.

Exercises (214):

1. Where can you find an indication of the heat-treatment a magnesium cast product received?

2. What is the rule for spacing specification markings on magnesium extrusions?

3. Break down the magnesium alloy designator HZ32A to its individual parts and explain the meaning of each part.

4. If the surface of a test strip turns black when silver nitrate is applied, what is the material composition of the test strip?

5. Why must you file the test strip first, before applying silver nitrate to it?

First part	Second part	Third part	Fourth part
Indicates the two principal alloying elements.	Indicates the amounts of the two principal alloying elements.	Distinguishes between different alloys with the same rounded-off percentages of the two principal alloying elements.	Indicates condition and properties.
Consists of two code letters representing the two main alloying elements arranged in order of decreasing percentage.	Consists of two whole numbers corresponding to rounded-off percentages of the two main alloying elements and arranged in same order as the alloy designations in the first part.	Consists of a letter of the alphabet assigned in order as compositions become standard.	Consists of a letter followed by a number (separated from the third part by a dash).
A—Aluminum E—Rare earth H—Thorium K—Zirconium M—Manganese Z—Zinc	Whole numbers.	Letters of alphabet except I and O.	F—As fabricated. O—Annealed. H24—Strain hardened and partially annealed. T4—Solution heat treated. T5—Artificially aged only. T6—Solution heat treated and artificially aged.

53-1309

Figure 2-7. Standard alloy designators system for magnesium (ASTM).

6. If no reaction occurs after applying silver nitrate to a prepared test strip, what is its material composition?

215. Define the terms "ferrous" and "nonferrous," and classify given metals into each group.

All metal may be classified as "ferrous" or "nonferrous." A ferrous metal is any metal that has iron as its main element. A metal is still considered ferrous, even though it contains less than 50 percent iron, as long as it contains more iron than any other metal. A metal is considered nonferrous if it contains more of any other metal than it does of iron.

Ferrous metals include case iron, steel, and the various steel alloys. The only difference between cast iron and steel is in the amount of carbon. Cast iron contains more than 2 percent carbon, while steel contains less than 2 percent. An alloy is a substance composed of two or more elements. Therefore, all steels are an alloy of iron and carbon, but the term "alloy steel" normally refers to a steel that also contains one or more other elements. For example, if the main alloying element is tungsten, the steel is a "tungsten steel" or a "tungsten alloy." If there is no alloying material, it is a carbon steel.

Alloy steels have been developed to meet the needs of modern industry for tougher, stronger, and harder steels than can be obtained in simple carbon steels. Alloys, such as nickel, chromium, tungsten, vanadium, manganese, and molybdenum, all give distinct properties to the steel; but, in all cases, the principal qualities are the increase in hardness and toughness.

Nonferrous metals include a great many metals that are used mainly for metal plating or as alloying elements, such as tin, zinc, silver, and gold. We are primarily concerned with the metals used in the manufacture of parts, such as aluminum, magnesium, titanium, nickel, copper, and their alloys.

Exercises (215):

1. Define the term "ferrous."

2. Define the term "nonferrous."

3. Identify the following metals as "ferrous" or "nonferrous."
   a. Aluminum:
   b. Copper:
   c. Gray cast iron:
   d. Chrome-molybdenum steels:
   e. Carbon steel:

f. Magnesium:
g. Titanium:

4. What does the term "alloy steel" generally refer to?

216. Explain or identify critical elements of the various methods used to identify steels.

Methods of Identification. As an airframe repairman, you must be able to recognize steels and their hardness and physical properties; a steel's physical properties decide its strength, safety, and corrosion resistance, and therefore, its suitability for a given use. The following numbering systems and color code, plus in-shop testing procedures, will help you select the proper steel for a given repair situation.

Society of Automotive Engineers (SAE) Numbering System. The SAE system of identifying steels is based on the use of four- or five-digit numbers. The *first* number indicates the type of steel; for example, 1 indicates a carbon steel, 2 nickel steel, etc. In the case of alloy steels, the *second* number—and sometimes the *third*—usually indicates the approximate percentage of the principle alloying element. The final *two* numbers—sometimes *three*—indicate the approximate carbon content in hundredths of 1 percent (0.01 percent). The SAE series numbers are given in figure 2-8. The following examples will help you understand this system:

TYPE OF STEEL	SAE NUMBERS
Carbon Steels	1XXX
Plain Carbon	10XX
Free Cutting, Manganese	X13XX
Free Cutting, Screw Stock	11XX
High Manganese	T13XX
Nickel Steels	2XXX
.50% Nickel	20XX
1.50% Nickel	21XX
3.50% Nickel	23XX
5.00% Nickel	25XX
Nickel-Chromium Steels	3XXX
1.25% Nickel : .60% Chromium	31XX
1.75% Nickel : 1.00% Chromium	32XX
3.50% Nickel : 1.50% Chromium	33XX
3.00% Nickel : .80% Chromium	34XX
Corrosion and Heat Resisting	30XXX
Molybdenum Steels	4XXX
Chromium-Molybdenum	41XX
Chromium-Nickel-Molybdenum	43XX
Nickel Molybdenum	46XX & 48XX
Chromium Steels	5XXX
.60% to 1.10% Chromium	51XX
1.2% to 1.5% Chromium	52XXX
Corrosion and Heat Resistant	51XXX
Chromium-Vanadium Steels	6XXX
Tungsten Steels	7XXXX & 7XXX
Silicon-Manganese Steels	9XXX

33-126

Figure 2-8. SAE series numbering system.

SAE-1045

1—Type of steel (carbon).
0—Percent of alloy (none).
45—Carbon content (0.45 percent carbon).

SAE-2330

2—Type of steel (nickel).
3—Percent of alloy (3 percent nickel).
30—Carbon content (0.30 percent carbon).

SAE-71650

7—Type of steel (tungsten).
16—Percent of alloy (16 percent tungsten).
50—Carbon content (0.50 percent carbon).

SAE-50100

5—Type of steel (chromium).
0—Percent of alloy (less than 1 percent chromium).
100—Carbon content (1 percent carbon).

AISI code. The American Iron and Steel Institute numerical code (AISI) is essentially the same as the SAE code. For example, SAE-1030 and AISI-C1030 are carbon steels of identical chemical composition. The two organizations have worked together in the past in expanding the SAE code to cover a greater number of specifications for ferrous metals. One difference between the two codes is that the prefix of an AISI number indicates the process used in the manufacture of the metal. The C in AISI-C1030 indicates that the steel is a basic open-hearth carbon steel.

AMS code. The Aeronautics Division of the SAE Standards Committee has developed the Aeronautical Material Specifications (AMS) code. These specifications are complete procurement specifications for materials used in the manufacture of aircraft, aircraft engines, propellers, and other aircraft accessories. The chemical and physical composition of AMS metals are coordinated as closely as possible with SAE general standards for similar metals. An example of an AMS number is AMS-5045B. The specification title for this number tells you that it is steel sheet and strip (low carbon, hard temper). AMS specification numbers indicate many detaild requirements in addition to the chemical analysis of the material. Revised or amended specifications are indicated by letter suffixes; e.g., AMS-5045B is the second revision of AMS-5045.

ASTM code. The American Society for Testing Materials numerical code (ASTM) has much in common with the Aeronauticals Materials Specification code. The ASTM specifications are also complete procurement specifications and have many detailed requirements in addition to the chemical composition of the materials. For example, A5-55 is an ASTM specification number in which the A denotes ferrous material. The 5 in A5 is the serial number for high-carbon steel joint bars, and the 55 following the dash indicates that the specifications were adopted or last revised in 1955.

Color coding. As with aluminum, a color code system has been developed to identify steels that are less than ½ inch in diameter (bars, tubing, etc.). Figure 2-9 shows the SAE color coding for steel. A piece of steel marked with colored 5-inch-wide stripes of black and white and a narrow 2-inch stripe of black is 4130 steel. The color code for 1020 steel is a wide red stripe and narrow yellow stripe.

Shop Identification. There are several methods of identifying unknown steels; however, you cannot use any of these methods to accurately determine the chemical composition of a metal. You can determine

BROAD STRIPE (5 inches)

Color	First digits of steel-numbers
Red	10
Red and Yellow	13
Yellow	23
Yellow and Green	25
Green	31
Green and White	40
Black and White	41
Blue and White	43
Red and Black	46
White	61
Black and Yellow	86
Black and Green	87

NARROW STRIPE (2 inches)

Color	Last two digits of steel-numbers
Red and Black	00
Red	10
Red and Green	12
Red and White	15
Yellow	20
Yellow and White	25
Black	30
Black and White	35
Green	40
Green and White	45
Blue	50
Blue and Brown	55
Brown	60
Brown and White	65
Olive Drab (Khaki)	95

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Figure 2-9. SAE color coding for steel. Table 18.

whether a metal is ferrous or nonferrous and whether steel has a low or high carbon content. The methods of shop identification that we will discuss are the spark and chemical tests.

Spark Testing. Spark testing is a common means of identifying various ferrous metals which have become mixed together in a scrap pile. In this test, use a bench or pedestal grinder and hold the piece of iron or steel against a fairly course and very hard grinding stone revolving at 3500 rpm or faster. Observe the sparks thrown off. Each ferrous metal has its own peculiar spark characteristics. The spark streams vary from a few tiny shafts to a shower of sparks several feet in length. (Few nonferrous metals, except titanium, give off sparks when touched to a moving grinding stone. Therefore, these metals cannot be successfully identified by the spark test.)

Steels produce spark streams that vary in length, shape, and color. The lengths may be as short as 10 inches or as long as 2 feet. The color will vary from a dull red to nearly white. The spark stream is made up of shafts, forks, sprigs, dashes, appendages, and bud break arrows, as shown in figure 2-10. Each stream may have few, many, or no sprigs. The length of the shaft may vary, it may not have any forks, bud break arrows, nor appendages. By observing the individual characteristics of the stream and comparing it with the spark stream of the known specimen, you can identify the metal quite accurately.

Wrought iron produces long shafts that are straw colored as they leave the stone and white at the end. Cast iron sparks are red as they leave the stone and turn to straw color. Low carbon steels give off long straight shafts having a few white sprigs. As the carbon content of the steel increases, the number of the sprigs along each shaft increases and the stream itself becomes white in color. Nickel steel causes the spark stream to contain small white blocks of light within the main burst.

Spark testing with the unknown sample alone is difficult. The best way to identify an unknown steel is to compare its spark stream with the spark stream of a known sample. Observing the spark stream against a dark background helps you to see the spark stream better.

Chemical testing. You can use the cupric chloride acid test to distinguish between nickel base alloys (inconel) and iron base alloys (18-8 stainless steel). The test solution consists of 10 grams of cupric chloride dissolved in 100cc or hydrochloric acid. (You can use cupric sulphate in place of cupric chloride.) Clean the metal thoroughly with emery paper; then place one drop of the acid test solution on the metal and allow it to remain there for 2 minutes. A green color will appear. Slowly add 4 drops of water to the acid on the metal until the green color disappears. Rinse and dry the sample. The acid solution will leave a small copper spot on steel or stainless steel. It will leave a bright shiny spot on nickel base alloys, such as inconel or monel.

The application of a drop or two of nitric acid will enable you to distinguish between stainless steel and hardened carbon or alloy steels. Nitric acid attacks hardened steel very rapidly; it attacks stainless steel very slowly.

Exercises (216):

1. Explain the meaning of the individual digits used in the SAE numbering system related to steel.

2. What is the main difference between the SAE numbering system and AISI coding system?

3. Why are specifications given in AMS and ASTM codings?

4. What would be the color coding for a piece of steel tubing whose main alloying element was 3 percent nickel if it has approximately 35 hundredths of 1 percent carbon content?

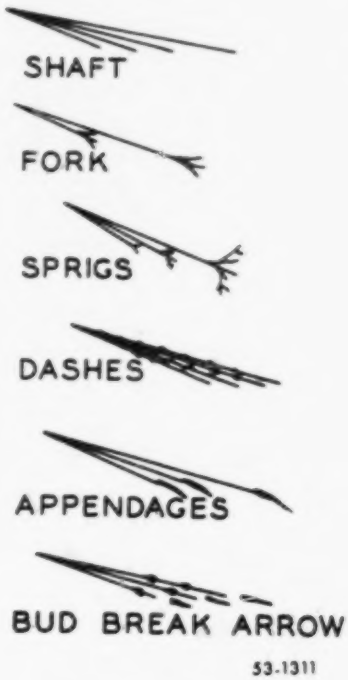


Figure 2-10. Spark testing terms.

5. What is the best method to employ when identifying steels using the spark test method?

6. Cupric chloride is used to identify what types of steels?

7. What factor is used to identify stainless steel from carbon or alloy steels when using nitric acid as a testing agent?

217. Classify the types of carbon steels, and associate important characteristics with given types of alloyed steels.

While steel of the plain carbon type remains the principal product of the steel mills, so-called alloy or special steels are being turned out in ever-increasing tonnage. As an airframe repairman, you will use these metals in your day-to-day work on aircraft, so let's consider those alloyed steels generally used in aircraft. Refer to figure 2-11 as we discuss the various types.

Carbon Steels. Steel containing carbon in percentages ranging from 0.10 to 0.30 percent is classed as low carbon steel. The equivalent SAE numbers range from 1010 to 1030. Steels of this grade are used for making such items as safety wire, certain nuts, cable bushings, and threaded rod ends. This steel in sheet form is used for secondary structural parts and clamps, and in tubular form for moderately stressed structural parts.

Steel containing carbon in percentages ranging from 0.31 to 0.50 percent is classed as medium carbon steel. This grade of steel is especially adaptable for machining for forging, and useful where surface hardness is desirable. Certain rod ends and light forgings are made from SAE 1035 steel.

Steel containing carbon in percentages ranging from 0.51 to 1.05 percent is classed as high carbon steel. The addition of other elements in varying quantities adds to

TYPES OF STEEL	SAE NUMBERS (General Series)	CHARACTERISTICS RESULTING FROM THE ALLOYING ELEMENT ADDED
Carbon Steels	1000	Surface Hardness and Strength
Nickel Steels	2000	Toughness
Chrome-Nickel Steels	3000	Toughness and Depth Hardness
Molybdenum Steels	4000	Eliminates Brittleness and Increases Depth Hardness
Chrome-Molybdenum Steels	4100	High Strength and Toughness
Chromium Steels	5000	Corrosion Resistance and Hardness
Chrome-Vanadium	6000	Depth Hardness and Toughness at Sub-Zero Temperatures
Tungsten Steels	7000	Hardness at High Temperature.
Chrome-Nickel-Molybdenum Steels	8000	Toughness and Strength - (General Purpose Steel)
Silicon-Manganese Steels	9000	Depth Hardness and Toughness Under Impact

Figure 2-11. General characteristics of steel.

the hardness of this steel. In the fully heat-treated condition, it is very hard, will withstand high shear and wear, and will have little deformation. Its use is limited in aircraft. SAE 1095 in sheet form is used for making flat springs and in wire form for making coil springs.

Nickel Steels. Nickel is one of the more dense of common metals used today. It is more dense than the common element, iron. It is only slightly magnetic and loses its ability to attract a magnet just above room temperature. The melting point of pure nickel is approximately 200°-300° F below that of pure iron. However, nickel is heat- and corrosion-resistant. It is not only resistant to extremely corrosive environments, such as salt water or oxidizing atmospheres, but resistant to damage as a result of prolonged contact with high temperature oxidizing atmospheres.

To some degree, corrosion resistance can be altered in nickel by the addition of alloying elements, such as magnesium, aluminum, silicon, copper, beryllium, molybdenum, and titanium. In some cases, not only does corrision resistance increase, but as a result of specific heat treatments, hardness, tensile strength, yield strength, and notch toughness increase.

Depending upon alloying elements, many different nickel base alloys are possible. Here, however, we will describe only the following groups: inconel, monel, K-monel, hastelloy, and nickel-cobalt base alloys.

Inconel. This group of nickel alloys are of the nickel-chromium-iron variety. These alloys contain between 72 percent and 82 percent nickel, 14 to 17 percent chromium, and about 6 to 10 percent iron.

Inconel is highly corrosive resistant, heat resistant, and exceptionally tough. It can be supplied with various finishes in bar, rod, sheet, or strip form in such conditions as hot rolled, cold rolled to various degrees of hardness, annealed, etc. Subzero temperatures do not decrease this alloy's strength, hardness, toughness, corrosion resistance, or impact strength. Inconel is more heat resistant that either monel or K-monel, and it may be obtained in either cast or wrought form.

Monel. Monel is one of the more commonly known nickel-copper alloys. Monel has a nickel content of 67 percent, 30 percent copper, plus small amounts of other minor alloying elements. It is obtained in various conditions and degrees of hardness. Cold-working is the only means of increasing the hardness of monel. If a part requires the strength induced by factory cold-working, it must not be welded or heated for forming purposes because the heating will anneal and remove the required strength, which cannot be replaced by any shop working procedure.

K-monel. K-monel is a nonmagnetic, age-hardening, nonferrous alloy containing 65 percent nickel and 30 percent copper, and about 3 percent aluminum, which gives it its age-hardening ability. Its strength and hardness are comparable with those of heat treated alloy steels. Its resistance to corrosion is similar to that of monel. It begins to melt at about 2400° F and is completely liquid at 2460° F.

Hastelloy alloys. This group of nickel-base alloys differs from the other nickel base alloys, in that it has a high molybdenum content. This series of alloys responds to solution heat treating and a precipitation treatment. The characteristics of this group of nickel-base alloys are similar to the other nickel-base alloys, except that it has outstandingly high temperature corrosion resistance, and is capable of high strength as well.

Nickel-cobalt base alloys. These heat and corrosion resistant nonferrous alloys are superior to all other heat and corrosion resistant alloys in areas of application where corrosion resistance at high temperatures is required. The mechanical properties of this alloy are not appreciably altered by heat up to 1800° F. Oxidation resistance of this alloy is excellent to approximately 2000° F. This is approximately 100°-150° F higher than the maximum service limit temperature for inconel. Alloys N-155 and L-605 are examples of this group of heat and corrosion resistant nonferrous alloys. These two metals find wide use in the TF-39 engine hot section area, enabling the metal in this engine to withstand high operating temperature in highly oxidizing atmospheres.

Chromium Steels. These are corrosion-resisting metals. The anticorrosive degree of this steel is determined by the surface condition of the metal as well as by the composition, temperature, and concentration of the corrosive agent.

Chromium steel is high in hardness, strength, and corrosion-resistant properties. SAE 51335 steel is particularly adaptable for heat-treated forgings which require greater toughness and strength than may be obtained in plain carbon steel. It may be used for such articles as the balls and rollers of antifriction bearings.

Chrome-nickel or stainless steels. The principal alloy of stainless steel is chromium. The corrosion-resisting steel most often used in aircraft is known as 18-8 steel because of its content of 18 percent chromium and 8 percent nickel. One of the distinctive features of 18-8 steel is that its strength may be increased by cold-working. Both nickel and chromium influence the properties of the steel; nickel toughens it and chromium hardens it.

Stainless steel may be rolled, drawn, bent, or formed to almost any shape. Because these steels expand about 50 percent more than mild steel and conduct heat only about 40 percent as rapidly, they are more difficult to weld. Stainless steel, with a slight variation in its chemical composition, can be used on almost any part of an aircraft. Some of its common applications are in the fabrication of exhaust collectors, stacks and manifolds, structural and machined parts, springs, castings, tie rods, and cables.

Chrome-vanadium steels. These are made of approximately 18 percent vanadium and about 1 percent chromium. When heat-treated, they have strength, toughness, and resistance to wear and fatigue. A special grade of this steel in sheet form can be cold-formed into intricate shapes. It can be folded and flattened without signs of breaking or failure. SAE 6150 is used for making springs; and chrome vanadium with high

carbon content, SAE 6195, is used for ball and roller bearings.

Chrome-molybdenum steels. Molybdenum in small percentages is used in combination with chromium to form chrome-molybdenun steel which has various uses on aircraft. Molybdenum is a strong alloying element. It raises the ultimate strength of steel without affecting ductility or workability. Molybdenum steels are tough and wear-resistant, and they harden throughout from heat-treatment. They are especially adaptable for welding, and for this reason they are used principally for welded structural parts and assemblies.

This type steel has practically replaced carbon steel in the fabrication of fuselage tubing, engine mounts, landing gears, and other structural parts. The main reason for this is that a heat-treated SAE 4130 tube is approximately four times as strong as an SAE 1025 tube of the same weight and size.

The popular series of chrome-molybdenum steel is that series containing 0.25 to 0.55 percent carbon, 0.15 to 0.25 percent molybdenum, and 0.50 to 1.10 percent chromium. These steels, when suitably heat-treated, are deep hardening, easily machined, readily welded by either gas or electric methods, and are especially adapted to high temperature service.

Exercises (217):

1. State the three classifications of carbon steel and percentage range of each class.

2. Of the nickel-base alloys, which one is the most outstanding in corrosion resistance at high temperatures?

3. Why can't monel be heat-treated to increase its hardness?

4. Which characteristic of K-monel is the result of alloying with aluminum?

5. What physical properties of stainless steel are increased by the alloying elements of nickel and chromium?

6. How may the strength of stainless steel be increased?

7. What factors affect the anticorrosive quality of chromium steel?

8. Molybdenum steels are especially adaptable to what metal working process?

9. Why is the welding of stainless steel considered difficult?

10. Besides being resistant to extremely corrosive environments, such as salt water or oxidizing atmospheres, what other characteristic is associated with nickel alloyed steels?

2-3. Heat-Treating Requirements

Earlier we talked about the physical properties of metal and how we must consider these properties in selecting a metal for repair situations. Now we're going to look into the methods used to alter these properties to fit a particular need during and after fabrication of repair parts.

The metal processing specialist (welder) will do the actual heat-treating of metal but you, as an airframe repairman, must know what can be accomplished by the different heat-treating processes.

Only those metals which you will most likely have heat-treated, are covered in this section. Specific information for heat-treatable metal can be found in TO 1-1A-9, *Aerospace Metals—General Data and Usage Factors.*

218. Cite specific results of two methods used to change the properties of aluminum alloys, and cite heat-treatment procedures and factors to consider in heat-treating aluminum alloys.

Cold-Working. If a piece of metal is formed (shaped or bent) while at room temperature, it is said to be cold-worked. If the metal is cold-worked too much, that is, if it is bent back and forth or hammered at the same place too often, it will crack or break. Nearly all the work you do with metal is cold-working.

Cold-working alters the properties of the metals. Cold-working increases the hardness of the metal. However, extensive cold-working increases the hardness of a metal to the point of brittleness, and eventual cracking or breaking. An increase in one property causes a decrease in another property. Even before

cracking occurs, cold-working reduces ductility and malleability as it increases hardness. The desired properties obtained by cold-working of non-heat-treatable aluminum are destroyed by any subsequent heating and cannot be restored except by additional cold-working, which is not always possible.

Heat-Treatment. Any process which involves controlling the heating and cooling of metals to develop certain desirable characteristics (such as hardness, softness, ductility, tensile strength, or refined grain structure) is called heat-treatment or heat-treating. Several of the aluminum alloys respond readily to heat-treatment. In general, this treatment consists of heating the alloy to a known temperature, holding this temperature for a definite time, then quenching the part to room temperature or below. During the heating process a greater number of the constituents of the metal are put into solid solution. Rapid quenching retains this condition, which results in a considerable improvement in the strength characteristics.

Aluminum alloy should be heated in an electric furnace or molten salt bath. The salt bath generally used is a mixture of equal parts of potassium nitrate and sodium nitrate. Parts heated by this method must be thoroughly washed in water after treatment. The salt bath method of heating should never be used for complicated parts and assemblies that cannot be easily washed free of the salt.

Hardening Procedures. Two types of heat-treatment are applicable to aluminum alloys: the *solution* treatment and the *precipitation* treatment. Certain alloys develop their full strength from the solution treatment while others require both treatments for maximum strength.

Solution treatment. The solution treatment consists of heating the metal to the temperature required to cause the constituents to go into solid solution, holding or soaking the parts at this temperature for a sufficient time to complete the solution, followed by rapid quenching in cold water to retain the condition. The time of transfer from the furnace to the quench tank must not exceed 7 seconds.

Precipitation treatment. The precipitation treatment consists of *aging* the parts previously subject to the solution treatment at a definite temperature for a considerable time. During the aging period a portion of the alloying constituents precipitate out in the form of extremely fine particles, greatly increasing the strength of the alloy.

Heat-treatment affects not only strength properties but also corrosion-resistant properties. It is possible to obtain the desired properties upon heat-treatment and yet fail to secure a maximum corrosion resistance by cooling too slowly. As little as 10° under the specified solution temperature may affect either the physical or corrosion-resistant properties or both.

Quenching and aging. Quenching from the elevated temperature causes some increase in strength and hardness, but the maximum values are not immediately obtained and ductility is hardly affected. While in this condition the alloy can stand a considerable amount of cold-forming without danger of rupture. After a period of approximately 1 hour, the effects of aging begin to reduce the ductility of the material, making it impractical to work the alloy. Aging is a natural characteristic of the metal and depends on time and temperature. At temperatures below 0° C (32° F) aging is greatly retarded and the material may he held in a workable condition for several days by means of refrigeration. At room temperature, however, the aging effect starts at once and continues over a period of several days, although it is practically complete in from 16 to 24 hours. 2014 is an age-hardened alloy, as are 2017 and 2024, but 2014 is artificially aged at a temperature of 166° to 182° C (330° to 360° F) for a period of 5 to 14 hours; it does not age harden at room temperature. Unless it is aged at the proper temperature, 2014 does not develop its full strength.

The results of the hardening process of heat-treating as well as the condition of the metal before heat-treating can be checked by hardness testing. There are two standard methods of hardness testing, the Brenell and the Rockwell, both of which require machines. The machinist can perform this testing when necessary.

Annealing. Annealing removes the strain hardening which results from cold-working and, in the case of the heat-treated alloys, removes the effect of the heat-treatment. Annealing is usually carried out in air furnaces, but salt baths may be used if the melting point of the bath is low enough. A bath made up of equal parts by weight of sodium nitrate and potassium nitrate is satisfactory.

Annealing work hardened material. Material that was initially in the soft or annealed condition but which has been strain-hardened by cold-working, such as 1100, 3003, 5052, etc., is annealed by heating the metal to a temperature of 349° ± 5° C (660° ± 10° F). It is necessary to hold the material at this temperature only for a sufficient length of time to make certain that the temperature in all parts of the load has been brought within the specified range. If the metal is heated appreciably above 354° C (670° F), there is a partial solution of the hardening constituents and the alloy will age harden on standing at room temperature unless it has been cooled very slowly. If the temperature is not raised to 343° C (650° F), the softening may not be complete. The rate of cooling from the annealing temperature is not important. However, a slow cool is desirable in case any part of the load may have been heated above the recommended temperature range.

Annealing heat-treated material (partial). If material in the heat-treated condition is annealed as described above, the effects of the heat treatment are mostly removed, but not completely. For less severe forming operations this partial anneal may be sufficient, but for complete softening the anneal described in the next paragraph is necessary.

Annealing heat-treated material (full anneal). For the complete removal of the effects of heat-treatment, heat the alloy to a temperature of 399° to 427° C (750° to 800° F) and hold it at this temperature long enough for all parts of the alloy to be at this temperature for at

least 1 hour. Allow the alloy to cool at a rate not greater than 28° C (50° F) per hour until the temperature has reached 260° C (500° F). The rate of cooling below 260° C (500° F) is not important.

Heat alclad parts as quickly and carefully as possible, because long exposure to heat causes some of the constituents of the core to diffuse into the pure aluminum coating, appreciably reducing the effectiveness of the pure aluminum as a corrosion-resistant material. During a single annealing treatment, do not heat alclad 2024 alloy to a temperature higher than 432° C (810° F), and don't keep it at that temperature more than 2 hours.

Exercises (218):

1. What physical properties are decreased when a piece of metal is cold-worked?

2. What are the results of excessive cold-working?

3. Will the physical properties of nonheat-treatable aluminum alloy, obtained by cold-working, be increased or decreased by annealing? Explain your answer.

4. Briefly define the term "heat-treatment."

5. What type parts should not be heated in a molten salt bath?

6. After solution treatment of aluminum alloys, what is the maximum transfer time to the quenching tanks?

7. Why should the temperatures for heat-treating be closely monitored?

8. State two situations that would require aluminum alloys to be annealed.

9. For what purpose is partial annealing usually sufficient?

10. What special precaution should be observed when heat-treating alclad aluminum alloys, and why?

219. List common errors in heat-treating aluminum and aluminum alloys, and cite possible causes for specific undesirable results.

Heat-Treating Troubles. The heat-treatment of aluminum alloys is a complicated process. You must closely control soaking times and temperatures. There are several causes for failures in the heat-treatment of aluminum alloys:

Overheating causes the part to blister. Blistered parts have poor strength and corrosion resistance. All blistered parts must be scrapped.

Underheating causes less than the maximum amount of copper to go into the solution. As a result, maximum hardness and tensile strength cannot be obtained.

Undersoaking, like underheating, does not allow maximum hardness and tensile strength to be developed. A maximum amount of copper has not been taken into the solution.

Oversoaking cuts down the corrosion resistance of clad products. A clad product is one that has a very thin coating of 1100 aluminum on all surfaces. 1100 aluminum has good corrosion resistance and protects the alloy that it covers. In fact, until the 1100 surface is damaged, the clad alloys have corrosion resistance equal to that of 1100 aluminum. During extended soaking periods, alloying elements move from the center portion out into the cladding. Oversoaking thus lowers corrosion resistance by changing the chemical composition of the cladding from pure aluminum to an aluminum alloy. The length of the proper soaking period depends upon the type of furnace, initial condition of the metal, and the size and shape of the parts you are heat-treating.

Reheat-treating has the same effect as oversoaking. Corrosion resistance of clad products is lost if they are reheated more than the allowable number of times. For thicknesses less than 0.125, the maximum number of reheat-treatments is one. For thickness over 0.125, two reheat-treatments are allowable.

Overaging causes a loss of strength, hardness, and corrosion resistance. It occurs when an aluminum alloy is aged at too high a temperature for too long a time. The copper aluminide particles become quite large during overaging.

Too much time taken in transferring the alloy from the furnace to the quench tank causes a loss of corrosion resistance in both clad and nonclad alloys. When the cooling rate is too slow, the alloying elements collect at the boundaries of the grains. This creates an ideal condition for one of the most severe forms of corrosion (intergranular corrosion). Holding sheet

stock with large tongs causes a loss of corrosion resistance and strength at the point where the stock is gripped with the tongs. Always use the smallest tongs with which the part can be held firmly and always hold the part by the edge only.

A part entering the quenching medium at an angle may warp. In large sheets there is always some warping during quenching. Warped parts may be straightened or roll leveled (running through rollers) or stretch leveled (pulling at the ends). You can easily straighten some parts by careful use of a rawhide mallet. Regardless of the method used, straighten the parts immediately after quenching. You can use fixtures to help prevent warping.

Improperly spaced parts will not heat evenly. Place the parts in the furnace so that air circulates equally throughout the load. Use grids or racks to insure even heating and to protect the hearth plate and make handling the work easier.

The quenching medium becomes too hot after many parts have been quenched. Never allow the water quench to become hotter than 100° F. Parts quenched in water at a higher temperature will have poor corrosion resistance.

Exercises (219):

1. List six reason for failure when heat treating aluminum alloys.

2. What will cause a part to warp when quenching?

3. What causes intergranular corrosion?

4. Match each undesirable heat treating effect in column B with its cause or causes in column A. (More than one cause may be cited.)

Column A	*Column B*
____ a. Loss of strength.	1. Overheating.
____ b. Lack of copper in metal.	2. Oversoaking.
____ c. Blistering.	3. Underheating.
____ d. Loss of hardness.	4. Undersoaking
____ e. Decrease in clad corrosion resistance.	5. Overaging.

220. Specify why heat-treating is performed on titanium alloys.

There are three basic procedures for heat-treating titanium alloys: stress-relieving; annealing; and solution treating, quenching, and aging.

Stress-Relieving. This is done to remove residual stresses developed during fabrication procedures. Stress-relieving is performed without loss of strength or ductility. It is done over a range of temperatures which vary with the specific alloy. These temperatures are approximately 600° F below the alloy's recrystallization temperature. When the higher temperatures of the range are used in heat-treating, shorter periods of time are used to get equal results. Welded alloys are stress relieved to help prevent cracking.

Annealing. The annealing of titanium alloys serves primarily to provide adequate toughness, maximum ductility at room temperature, dimensional and structural stability at high temperatures, and improved machinability. Many titanium alloys are used in the annealed condition.

The annealing procedure is: heat the alloy to slightly below its recrystallization temperature, approximately 300° F below; soak it for a period of 30 minutes to 8 hours, depending primarily on the specific type of alloy; and air cool it.

Solution Treating, Quenching, and Aging. Several types of titanium alloys can be heat-treated to high strength and yet retain useful ductility. This combination of properties is usually obtained by solution treating, quenching, and aging.

Solution treating. To obtain high strength and adequate ductility, it is necessary to solution treat in the alpha-beta temperature range, which for commercial alpha-beta alloys is approximately 1400° to 1850° F (normally 50° to 100° F below transformation temperature). Altering the solution temperature alters the amount of beta phase and so changes the aging response. Selection of the solution temperature is usually based on practical considerations, such as the length of time required for aging and final ductility desired. The higher the solution temperature, the higher the final strength, but the lower the final ductility.

Quenching. The rate of cooling from solution temperature affects titanium much like it affects aluminum alloys. If the rate of cooling is too slow, the alpha is not trapped in the beta and a loss of final strength results. Alloy Ti-6Al-4V is the most critical commercial alloy; it must be cooled from solution temperature (approximately 1700° F) to 1000° F in no more than 1.5 seconds to develop maximum strength after aging. To achieve this, most titanium alloys require a water quench after solution treatment.

Aging. The final step in heat-treating titanium alloys to high strength consists of an artificial aging. Aging causes the partial decomposition of the supersaturated beta phase, which was retained from quenching. This decomposition (or precipitation) is not complete, but it does produce adequate strength and ductility.

Exercises (220):

1. When solution heat-treating titanium alloys, what type of quench is necessary to achieve maximum strength?

2. What does aging do when solution heat-treating titanium alloys?

3. List the three basic procedures for heat-treating titanium alloys.

4. At approximately what temperature is stress-relieving performed on titanium alloys?

5. How is strength and ductility produced when heat-treating titanium alloys?

6. Why are titanium alloys stress-relieved?

221. Cite the main factors involved in the heat-treating processes used for nickel-base alloys.

Annealing. Annealing is performed on nickel-base alloys by heating the alloy to a required temperature between 1300° and 2200° F and soaking for a predetermined period of time. After the alloy has been soaked, it is cooled slowly or rapidly to produce the desired mechanical properties. The annealing temperature, soaking period, and cooling rate are determined by the composition of the alloy. The technical order for the particular alloy tells you the precise temperature, time, and cooling rate required.

Stress-Relieving. This heat-treatment is reserved for those compositions that will not harden as a result of normal heat-treating. The stress-relieving temperatures are below the normal full annealing temperature. This is to say that this operation resembles tempering of steel in that it is performed below the recrystallization temperature of the alloy. A stress relief anneal is usually performed on hot-worked or severely cold-worked inconel where reduction in hardness is not desired or required. It may be given this treatment by heating to not over 800° F for approximately 3 hours. Air cooling after stress-relief annealing is usually satisfactory but fast quenching in water results in less scaling from the dead soft annealing temperature. The quench does not affect the hardness, but it may cause some warping.

Solution Heat-Treating and Age-Hardening. Solution heat-treating and age-hardening are not required with nickel base alloys. However, adding certain alloying elements to nickel, such as silicon, titanium, aluminum, copper, and magnesium, increases the alloy's response to age-hardening. An increase in hardness and strength is due to the precipitation of submicroscopic particles throughout the grains when age hardening is done. This age-hardening is performed by holding the alloy at temperatures above 900° F and then furnace or air cooling. Quenching is not required to achieve age-hardening. This heat-treatment can be done from the hot- or cold-worked conditions as well as from the soft condition.

Exercises (221):

1. What determines the soaking period for annealing nickel-base alloys?

2. What elements can be added to nickel-base alloys to increase the response to age-hardening?

3. What kinds of nickel-base alloys are stress-relieved?

4. What advantage does quick quenching have over slow air cooling when stress-relieving inconel?

5. What causes the increase in hardness and strength when age hardening nickel-base alloys?

6. What is the soaking temperature range when annealing nickel-base alloys?

7. Is stress-relieving of nickel-base alloys performed above or below its recrystallization temperature?

8. When can solution heat-treating and age hardening of nickel-base alloys be performed?

2-4. Working Characteristics of Metals

Being able to identify and select the correct metal for the repair or fabrication of a part is just the starting point. The working characteristics of the metal should be thoroughly considered before the operation of shearing, forming, grinding, drilling, sawing, and nibbling. If you use the correct methods, you will insure proper fabrication and also prolong the life of the tools and machinery that you use.

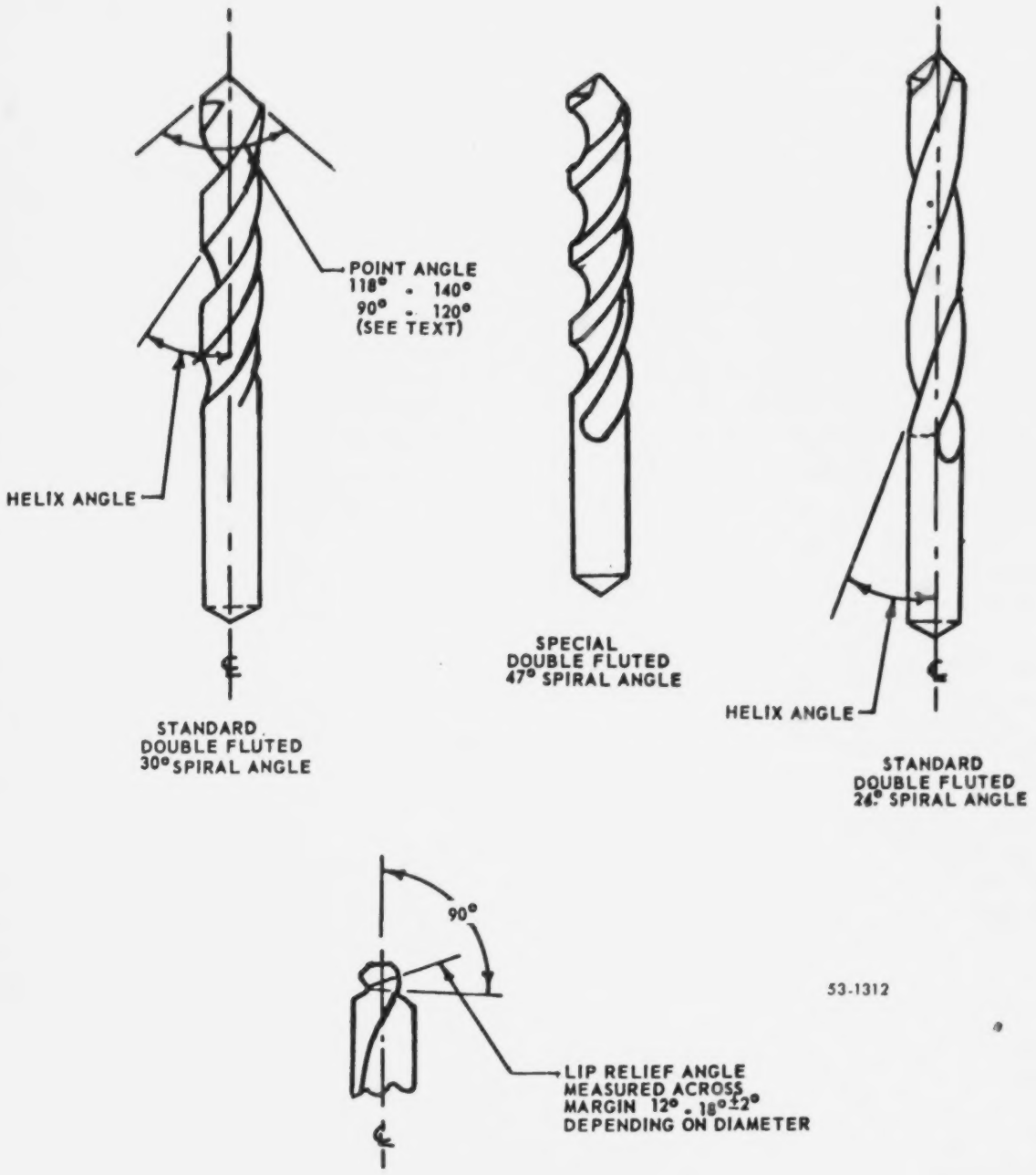


Figure 2-12. Twist drill designs and recommended cutting angles for aluminum.

222. Give the type of tools used for drilling and cutting aluminum, and give the reasons for specified procedures and tool characteristics.

The working characteristics of aluminum are such that several precautions are taken to insure a safe and usable product after fabrication processes are completed.

Drilling. Standard type twist drills may be used satisfactorily for many drilling operations in aluminum alloys. However, better results can be obtained with improved designed drills where soft material and drilling of thick material or deep holes are involved. These drills are usually designed having more spiral twists per inch (see center bit in fig. 2-12). The additional spiral twist gives more worm action or force, causing the drill to cut and feed faster. The added force is also helpful in

removing chips, especially in deep hole drilling operations. A double-fluted twist drill with a spiral angle of 47° gives good results on aluminum alloys.

The drilling of thin material normally does not require coolant/lubrication. However, adequate lubrication is essential to drill life and hole quality when drilling holes of ¼-inch depth or more. Soluble oil emulsions and lard oil mixtures are satisfactory for general drilling. The lubrication should be applied by forced feed spray or flow where possible and the drill should be withdrawn at intervals to be sure lubricant flows to the drill tip.

Reaming. Generally, most of the different type reamers may be used for aluminum, but for best results the spiral fluted reamers are recommended—solid, expansion, or adjustable. The spiral should be opposite to the rotation to prevent reamer from feeding and hogging into the hole. Holes to be finished by reaming should be drilled sufficiently undersize to assure positive cutting rather than scraping and swedging. The usual indication of oversize drilled holes and improper feed is the projection of a lip around the hold diameter after the reaming operation.) Finish reamers should be maintained with exceptionally keen cutting edges and highly polished flutes for smooth work.

The following procedures and tools are recommended for reaming aluminum alloys:

a. Tool material: High carbon steel drills for general use; high speed steel or carbide tipped drills for durability and continued production jobs.

b. Tool type: Straight spiral with 10° spiral flute and solid teeth.

c. Clearance and rake angles: Top rake 5° to 8°; primary clearance angle 4° to 7°; secondary clearance angle 15° to 20°; cutting angle 84° to 90°.

d. Machine speed and hole reaming allowance: Cutting speeds can be up to 400 ft/min for straight holes. Tapered hole should be cut somewhat slower, about 300 - 350 ft/min. The desired feed in inches/revolution is 0.003 to 0.010. The diameter of the hole to be reamed should be undersize 0.005 - 0.015 inch (reaming allowance).

e. Cutting fluids: Soluble oil—either lightweight machine oil or mixture of kerosene and lard oil.

Shearing. The accuracy of shearing is affected by the thickness of material, type of shear or knife blades, condition of the material, adjustment and sharpness of blades, size of cut, and the relationship of the width of the cut to sheet thickness.

Normally, most aluminum alloys can be sheared ½ inch and less in thickness except for the harder alloys, i.e., 7075-T6 and 7178-T6. These alloys have a tendency to crack in the vicinity of the cut especially if the shear blades are dull or nicked. In the case of 7075-T6 and 7178-T6, the limiting thickness is about 0.100 inch rather than ½ inch. Correct clearance between shear blades is important for good shearing. Too little clearance quickly dulls or otherwise damages the blades or knives; too much clearance causes the material to be burred, or even to fold between blades. Normal clearance is from one-tenth to one-eighth the sheet thickness. You can prolong blade life by occasionally lubricating. When the capacity of shear is doubtful, consult the shear manufacturer.

Sawing. Saw blades of spring temper steel having a tooth spacing of from 4 to 11 teeth per inch and amply radiused gullets are recommended for aluminum alloys. In any type of work, high blade speeds are desirable with a speed range from 1,500 to 5,000 feet per minute. For heavy sections the saw teeth should be fairly coarse with a slight set and a slight amount of front rake. The restricted chip space requires the use of coarser tooth spacing of about 4 teeth per inch to avoid clogging and binding. Another type of saw for heavy work is the flexible back type of saw with teeth hardened to the bottom of the gullet. Blades having as many as 14 teeth per inch are satisfactory for thin materials. A good and simple general rule to follow when sawing aluminum is that the spacing of the teeth on bandsaws for aluminum should be as coarse as is consistent with the thickness of the material being sawed. The softer alloys require appreciably more blade set than do the harder, heat-treated alloys. Usually, an alternate side rake of about 15° and a top rake or "hook" of 10° to 20° proves quite satisfactory. This amount of hook, however, requires a power feed and securely clamped work. For hand feeds, the top rake must be reduced considerably to avoid overfeeding.

The bandsaw blades must be well supported by side rollers and back support both immediately below the saw table and about 2 or 3 inches above the work. Place the top blade supports slightly in advance of those below the tables and allow the blade to vibrate freely to eliminate excessive saw breakage. As a general rule, a noisy bandsaw is cutting more efficiently than the saw that cuts quietly. Quiet smooth cutting band saws usually produce smooth burnished surfaces accompanied by excessive heat and consequently decreased blade life.

Hacksaw blades of the wavy set type are well suited for cutting aluminum by hand. The wavy set type of blade having 5 to 15 teeth per inch has sufficient chip space to avoid clogging and binding on aluminum alloys. For extremely fine work, you can use a jeweler's blade.

Forming. Through proper choice of alloy, temper, forming methods, and tools, a variety of forming operations can be performed on aluminum alloys. Ordinary types of presses, brakes, and rolls are suitable for the work. To reduce the possibility of cracking, sand and file any sheared or cut edges before bending or forming to reduce the possibility of cracking. Also form the metal across the direction of the grain flow when possible.

Filing. Hand files of the single cut type having milled teeth usually give the best results for filing aluminum. The main consideration in file selection for aluminum is to provide ample chip space clearance. The cuttings generated are large and have a tendency to powder, pack, and clog between file teeth. To overcome the clogging problem, select a file with increased chip

space, deeper cut grooves, and teeth cut with generous side and top rake.

Machine filing using rotary files (miniature milling cutters having spiralled sharp teeth with smooth, deeply cut flutes) are operated at high speed. The rotary files are operated up to 10,000 RPM for small diameter and to 2,000 maximum peripheral feet/min for the larger diameter. The teeth should be coarse (about 14 teeth per inch) with deep polished flute and spiral notched design.

Grinding. The grinding characteristics of aluminum alloys vary from one alloy to another. You can satisfactorily grind the harder free-cutting aluminum alloys with free-cutting commercial silicon carbide grinding wheels such as crystalon, carborundum, and natalon. Rough grinding operations are usually performed by the use of resin bonded wheels of medium hardeners and grit sizes of 24 to 30, and by the use of aluminum abrasives from No. 14 to No. 36. Aluminum abrasives from No. 14 to No. 36 have also been found satisfactory for rough grindings.

For finish work, a good combination is a soft silicon carbide wheel of 30 to 40 grit in a vitrified bond. A grinding compound of soluble cutting oil and water works well. However, the fine grindings of aluminum must be strained from the compound before reusing in order to prevent deep scratches on the finished surface.

Aluminum alloys, particularly in their softer tempers, have a tendency to clog the wheels and do not finish to as bright and smooth a surface as the harder materials.

Be careful to select the proper grade of each commercial make of wheel. Once the grinding wheel has been selected there are three variables that affect the quality of a finish; these are the wheel speed, work speed, and grinding compound. The good judgement of an experienced operator is the best thing for determining the correct wheel and work speeds; however, wheel speeds of about 6,000 feet per minute have given good results.

Polishing. Polishing or finishing aluminum and most of its alloys by the application of proper machining procedures gives a smooth lustrous finish. Aluminum and its alloys are polished in the same manner as other metals, but a lower wheel-to-metal pressure is used for aluminum.

Exercises (222):

1. Why are twist drills with more spiral twist per inch preferred when drilling aluminum alloys?

2. When is a coolant or lubrication required when drilling aluminum alloys?

3. What is the required spiral angle for twist drills used to drill aluminum alloys?

4. What is the reaming allowance for aluminum alloys?

5. How do you prevent scraping and swedging when reaming aluminum alloys?

6. Why can't aluminum sheets of ½ inch in thickness, and T-6 temper condition, be sheared?

7. What is the rule to follow when sawing aluminum alloys?

8. Why is a noisy bandsaw more efficient than a quiet, smooth cutting bandsaw?

9. What type of blade set is recommended for cutting aluminum alloys with a hacksaw?

10. Why must ample chip space clearance be provided when filing aluminum alloys?

223. Describe tools and working practices recommended for use with titanium, and the probable results of not following specified recommendations.

Working Characteristics. Although titanium presents no serious or complex problems during the working process, the characteristics of this metal should be thoroughly considered prior to the operations of shearing, forming, grinding, drilling, and sawing.

Shearing. Titanium and its alloys can be successfully sheared if the shear blades are in perfect condition. Shears used for cutting steel can be used to cut titanium if the shear blades are sharp and in good adjustment. Overallowances must be added when shearing titanium. Overallowance is the additional material added to the final dimension that must be sanded off

after shearing. Otherwise, stress risers will cause a tear in the part during forming operations. For gages up to 0.040 inch, 0.010 inch removal is sufficient. For gages over 0.040 inch, 0.020 to 0.025 inch must be removed from the sheared edge.

Shearing operations compare to those of 18-8 stainless steel in the ¼ hard condition for commercially pure titanium, and the titanium alloys compare to ½ hard stainless steel. The force required for titanium and its alloys is greater and the shear blades wear faster. Power contour shears, power roll shears, and unishears may be used.

Forming. You can form unalloyed titanium at room temperatures, using approximately the same procedures as those established for 18-8 stainless steel. The basic difficulties encountered are sheet thickness, property variations, and direction of grain flow. The above factors, combined with high yield strength, high tensile strength, and low uniform elongation of commercial titanium alloys, make forming difficult. The equipment currently available was designed for material of uniform quality, and considerable work is required for adaptation to titanium.

By using the methods developed for stainless steel, you can do straightedge bending of titanium to a limited degree using a power brake or hand-forming equipment. Compensation for springback and the bend radii are the factors which require control. Springback is comparable to that of hard stainless steel when formed at room temperature. The bend radii depend on the type of alloy and whether forming is done hot or cold.

Forming material which requires tight bends or small radii requires heat in the range of 500° F. Apply the heat only for short periods of time to avoid excessive oxygen and nitrogen contamination which causes embrittlement. Dimpled sheets, parts with less than 15° formed angles, or bent parts with radii greater than 15 times the thickness of the metal do not require stress relieving or annealing after cold-working.

Finished parts and materials to be formed must be free from shear cracks, tool marks, or other notches caused by cutting operations. All burrs must be removed. Edges to be formed must be filed free of burrs, grooves, scratches, and sharp corners. Imperfections may be removed by sawing, sanding, milling, or reaming. In edge preparation, make sure that the defects are removed and not merely covered over with smeared metal. On edges to be formed, you must do the final sanding with No. 240 grit or finer abrasive sheet. Do the final sanding of other edges with No. 120 grit or finer abrasive sheet. Abrasive marks on edges must be as nearly parallel to the sheet surface as practicable. Be careful to keep your edge finishing from excessively heating the metal. Heating accompanied by a blue discoloration is excessive. However, discoloration totaling no more than ½ inch in any 6 consecutive inches of edge length will not cause rejection of parts, provided that the discoloration does not extend more than ⅛ inch back from the edge. Round all edges to be formed as necessary to insure satisfactory forming. Edge radii of approximately 0.312-inch are recommended.

Grinding. Grind titanium and its alloys at approximately the same rate of speed as hardened high-speed steels and die steels. Moderately light cuts are recommended (periodic dressing is required to keep the wheel in proper condition). The frequency of dressing depends upon grinding conditions. Excessive wheel loading is likely to cause poor grinding action with subsequent poor surface finish, high residual tensile stresses, and low grinding ratios.

Grinding removes metal slowly and gives a poor surface finish with heavy burring. Titanium is very susceptible to cracking if the heavy burring is not removed by sanding before forming. Sand only by hand, using hand-held tools or hand-held parts, and use only aluminum oxide or silicon carbide abrasives. For surface finish requirements, a maximum grit size of No. 120 is recommended.

Grinding difficulties can be minimized by employing the proper type wheels at low wheel speed and feeds, and by flooding the grinding area with an inhibitor or purging type of cutting fluid. Keep grinding temperature low to keep stresses low.

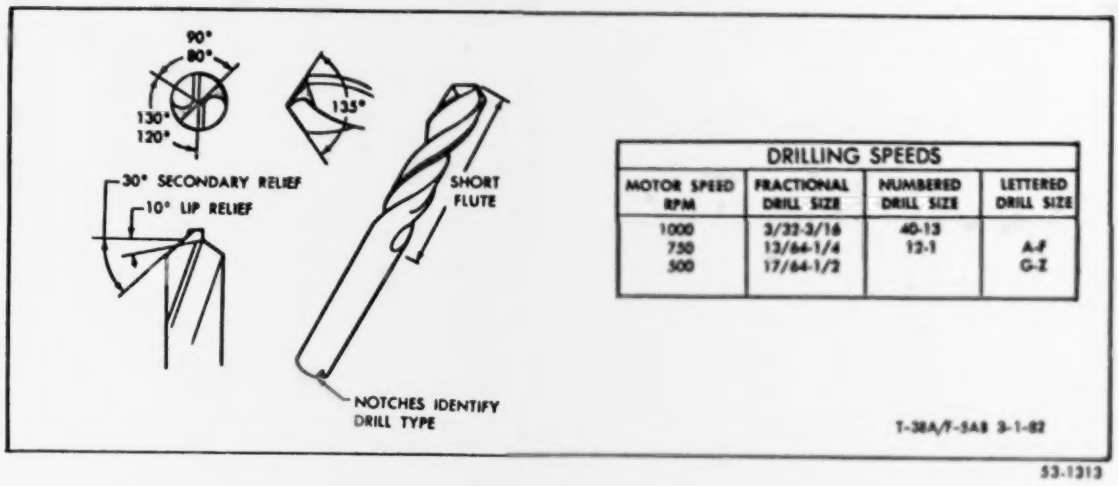
Drilling and reaming. Titanium and its alloys may be difficult to drill and ream unless you follow certain procedures carefully. An important factor in drilling and reaming holes in titanium is to apply enough power and pressure to keep the tool cutting until the hole is completed. If the drill is allowed to *ride* in the partial drilled hole, the area will work-harden, and further drilling will be extremely difficult if not impossible.

Use a power feed setup, such as a drill press, when possible. It is recommended that you use the shortest twist drill possible for the job.

Use specially ground twist drills when drilling titanium. The best type is a short, two-fluted, high-speed twist drill ground to a 135° split point. Figure 2-13 shows an example of this type twist drill and recommended speeds. High speed, spiral fluted reamers are required at cutting speeds at about half those for drilling. Carbide twist drills, reamers, and other cutting tools are recommended. Use a cetyl alcohol stick or Corsolube lubricant when drilling each hole, and clean the chips from cutting lips after each hole is completed. Do not attempt to use a twist drill that is chipped or dull.

To loosen and remove a broken tool such as a twist drill from titanium, submerge the part in a saturated solution of ferric ammonium sulfate or nitric acid. Use all precautions to avoid scratches because scratches lead to cracks and part failure. Blend out long, deep scratches using abrasive sheet or emery cloth No. 120 grit or finer.

Sawing. Power hacksaws, bandsaws, and friction saws are used for sawing titanium and its alloys. Fairly heavy pressure is needed because there is a tendency for the surface of the metal to harden if the blade is permitted to ride across the metal. During sawing operation, the metal may have a tendency to tear and



DRILLING SPEEDS

MOTOR SPEED RPM	FRACTIONAL DRILL SIZE	NUMBERED DRILL SIZE	LETTERED DRILL SIZE
1000	3/32-3/16	40-13	
750	13/64-1/4	12-1	A-F
500	17/64-1/2		G-Z

Figure 2-13. Twist drill design and recommended speeds for drilling titanium.

clog the saw blade. Use water-soluble coolants when sawing titanium.

Exercises (223):

1. What is meant by the term "overallowance"?
2. What factor determines the amount of overallowance?
3. In what direction must the abrasive marks on the edges of titanium run?
4. What is the maximum amount of allowable discoloration caused by edge finishing?
5. If the grinding wheel used to grind titanium is not periodically dressed, what are the results?
6. How can difficulties be minimized when grinding titanium?
7. What condition results from allowing a twist drill or saw blade to ride over the material to be cut?
8. Describe the recommended twist drill for drilling titanium.
9. How should long, deep scratches be removed from titanium?
10. When sawing titanium, what type of coolant is desired?

224. Describe specific tools and working practices associated with magnesium, and give the reason for specified practices.

Working Characteristics. The working characteristics of magnesium are similar to those of other metals. Magnesium may be worked by using the same methods and equipment as used on steel and aluminum, except that in most instances, magnesium can be worked more easily at high temperatures. Magnesium alloys are difficult to form at room temperature. Operations other than the most simple ones must be performed at higher temperatures. This requires preheating the metal or the dies or both.

You can cut magnesium alloy sheets with blade shears, blanking dies, routers, or saws. Use hand or circular saws for cutting extrusion to length. Never use conventional shears and nibblers for cutting a magnesium alloy sheet, because they produce a rough, cracked edge.

Cutting. Shearing and blanking require close tool tolerances. A maximum clearance of 3 to 5 percent of the sheet thickness is recommended. Grind the top blade of the shears with an included angle of 45° to 60°. Make sure the shear angle on a punch is 2° to 3°, with a 1° clearance angle on the punch. Don't do cold-shearing on hard-rolled sheet thicker than 0.064 inch or annealed sheet thicker than 0.125 inch. To improve the characteristic rough, flaky edge of magnesium sheet which has been sheared, "shave" it by removing approximately 1/32 of an inch with a second shearing.

Hot-shearing is sometimes used to obtain an improved sheared edge. This is necessary for heavy sheet and plate stock. You can heat annealed sheet to 600° F, but keep hard-rolled sheet under 400° F, depending on the alloy used. Thermal expansion makes it necessary to allow for shrinkage after cooling, which means adding a small amount to the cold metal dimensions.

Sawing. Sawing is the only method used in cutting plate stock more than ½-inch thick. Use bandsaw raker-set blades of 4 to 6 tooth pitch for cutting plate stock or heavy extrusions. Small and medium extrusions are more easily cut on a circular cutoff saw having 6 teeth per inch. You can cut sheet stock on bandsaws having raker-set or straight-set teeth with a pitch of 8 teeth per inch. Make sure band saws are equipped with nonsparking blade guides to eliminate the danger of sparks igniting the filings.

Drilling. The machining characteristics of magnesium alloys are excellent. Usually, you can use the maximum speeds of machine tools with heavy cuts and high speed rates. Power requirements for magnesium alloys are about ⅙ th of those for mild steel.

Three types of drills are used to obtain best results. For sheets, the recommended drill has a 60° point angle, 10° helix angle, and 120° to 135° chisel edge angle. For shallow holes, with a depth of less than five times the drill diameter, use a drill with a 70° to 118° point angle, 10° to 30° helix angle, 120° to 135° chisel edge angle, and 12° relief angle. For deep holes, the recommended drill has 118° point angle, 40° to 45° helix angle, and 135° to 150° chisel edge angle. A mineral base cutting oil facilitates drilling and is used when drilling deep holes. You can use the maximum speeds obtainable on drilling equipment, up to 2000 feet per minute, for magnesium alloys.

Grinding. Rough grinding, although not widely used, can be done on magnesium to remove rough edges, or to shape a piece of magnesium alloy. Use a coarse grained, medium hard, open structure wheel to avoid loading and to provide rapid cutting. Always wear goggles while you are grinding. Magnesium grindings and dust are very flammable, so you *must* use dust-collecting equipment. And you should ordinarily grind magnesium dry to facilitate dust collection.

The grinding of magnesium, as well as some of the machining operations, will produce highly inflammable dust which, in the proper proportions with air, can ignite with explosive violence. Rough cuts usually produce chips of such size that they do not readily ignite. Fine cuts at high speeds, with dull or improperly designed tools, produce chips that may ignite. It is extremely important that you take the utmost precautions to avoid a fire.

On heavy stock, use a sufficient quantity of neutral mineral oil cutting fluids. It is hazardous to use animal, vegetable, acid-containing oils, or any form of water emulsion as a coolant or lubricant, except a mixture of kerosene and lard oil.

Don't allow magnesium chips and dust to accumulate on the machines OR your clothing. Keep machines and the adjacent floor areas clean. Immediately remove the dust of grinding operations from the working area. Keep open flames and sparks away from finely divided magnesium at all times. And neither smoke nor permit smoking near magnesium machining operations.

Grinding equipment should be marked "For Magnesium Only." Do not grind iron, steel, or other metals on equipment used for magnesium because of the danger of producing sparks. Do not use sandpaper or emery cloth for any polishing operations. (The use of emery cloth is not recommended because of its tendency to cause sparking.)

Grinding and filing of magnesium surfaces which have been chrome-pickled may cause sparks. You must observe special precautions to avoid accumulation of dust within the range of sparks, especially magnesium dust on benches, floors, window ledges, pipes, and the like. And do NOT use vacuum cleaners to collect the magnesium dust. The dust should be swept up and placed in covered iron containers, and must not be mixed with the regular floor sweepings.

An adequate supply of the recommended fire substances should be placed near the machine being used. Recommended extinguishers are: G-1 powder; clean, dry, unrusted cast iron chips; graphite powder; clean, dry, sand; talc, or pitch.

If you should have a fire while working with magnesium, sprinkle extinguisher material over the fire in a layer approximately ½ inch deep. Add additional material to spots that smoke excessively. If the fire is on a combustible surface, cover it with extinguisher material and shovel the entire mass into an iron container.

WARNING: Never use water or any of the standard liquid or foam type, extinguishers, because they will intensify the fire and may cause an explosion.

Forming. As previously discussed, pure magnesium does not have sufficient strength to be used for structural purposes; but, as an alloy, it has a high strength-to-weight ratio. Its strength is not affected by subzero temperatures, and this increases its adaptability to aircraft use. Its nonmagnetic property makes it valuable for instrument cases and parts.

While magnesium alloys can usually be found by methods similar to those used on other metals, it must be remembered that many of the details of shop practice cannot be applied. Roughly, the same differences

as we pointed out for cutting apply to forming as well. Some simple bending operations may be performed on sheet material, but the radius of bend must be at least 7 times the thickness of the sheet for soft material and 12 times the thickness of the sheet for hard material. A radius of 2 or 3 times the thickness of the sheet can be used if the material is heated for the forming operation.

Wrought magnesium alloys tend to crack after they are cold-worked. Therefore, the best results are obtained if the metal is heated to 450° F. before any forming operations are attempted. Parts formed at the lower temperature range are stronger because the higher temperature range has an annealing effect on the metal.

There are some disadvantages to hot-working. First, heating dies and heating the material is expensive and troublesome. Secondly, there are problems in lubricating and handling materials at these temperatures. However, there are some advantages to hot-working magnesium in that it is more easily formed when hot than other metals and springback is reduced, resulting in greater dimensional accuracy.

When heating magnesium and its alloys, watch the temperature carefully, as this metal burns easily. Overheating also causes small molten pools to form within the metal. In either case, the metal is ruined. To prevent burning, magnesium must be protected with a sulfur dioxide atmosphere while being heated.

Proper bending around a short radius requires the removal of sharp corners and burrs near the bend line. Make layouts with a carpenter's soft pencil, because any marring of the surface may result in fatigue cracks.

It is permissible to heat small pieces of magnesium alloy with a blowtorch, provided you take proper precautions. Remember that magnesium ignites when it is heated to a temperature near its boiling point in the presence of oxygen.

You can use press or leaf brakes for making bends with short radii. Use die and rubber methods where bends are to be made at right angles, which complicate the use of a brake. You can do roll-forming cold on equipment designed for aluminum alloys. The most common method of forming and shallow drawing magnesium is an operation in which a rubber pad is used as the female die. This rubber pad is held in an inverted steel pan which is powered by a hydraulic press ram. The press exerts pressure on the metal and bends it to the shape of the male die.

Exercises (224):

1. What is the required squaring shear blade clearance for magnesium?

2. How many teeth per inch are required on the saw blade for cutting small and medium magnesium extrusions?

3. Describe the twist drill used to drill shallow holes in magnesium.

4. Why should the grinding equipment used to grind magnesium be marked "For Magnesium Only"?

5. How much larger must the bend radius be for cold-forming hard magnesium alloys than the bend radius required to cold-form soft magnesium alloys?

6. What temperature offers the best results for hot forming magnesium?

7. Why is it recommended that magnesium be ground dry?

8. How does the power requirement for magnesium-working equipment compare with the power required for working mild steel?

9. If you had a sheet of magnesium ½ inch thick, how would you cut it?

10. Why is a second shearing operation sometimes required when shearing magnesium?

225. Describe standard working practices, including tool selection, for working stainless steels.

Working Stainless Steels. The working of stainless steels is similar to the working of other metals. You must take special precautions in cutting, drilling, bending, and punching. The pressure required for working stainless compared to mild steel is about doubled. The corrosion-resisting steels, especially the 18-8 grades, are more difficult to work than the carbon steels and other metals. Even though they are difficult to work, the same general methods are used with modification or compensation for the individual characteristics of each type or grade.

Drilling corrosion-resisting steel. High-speed drills are commonly used for drilling stainless steel. Special types are used for drilling grades 420, 440, etc., that are abrasive due to high carbon content. Drilling speeds for these types are usually reduced 25 to 50 percent in comparison with the other grades.

Drills for use with the corrosion-resisting steels are prepared with different cutting angles than are used with carbon steel. Drill points or tips for use with the chromium-nickel grades are ground with a 135°-140° included angle and 8° to 15° lip clearance. The web support for the point should be as heavy as possible; however, thinning of the web at the point will relieve point pressure. When you drill the free machining 400 series grades, reduce the angle to 118° to 130° included angle.

When you drill the corrosion-resisting steels, control the speed to prevent hardening of metal and excessive drill damage from heat. Lubrication for drilling stainless steel is recommended. Use soluable oil for general and light drilling, and sulphurized mineral or fatty oils for heavy work. It is extremely important to use adequate lubrication or coolant in drilling stainless steel because of its poor heat conduction.

Reaming corrosion-resisting steel. The recommended reamer for the corrosion-resisting steels is the carbide tipped, spiral fluted type made from high-speed steel. These special fluted reamers are used to help alleviate the chatter and difficult chip removal associated with the straight fluted reamers.

Due to the work-hardening characteristics of corrosion-resisting steel, leave sufficient stock to insure that cutting will be behind the work-hardening surface resulting from drilling.

Reamers for cutting stainless steel should have a 26° to 30° starting chamfer, with a slight lead angle behind the chamfer of 1° to 2° for about ⅛ to 3/16 inch on the land to reduce the initial shock of cutting. The land should be ground with a clearance of 4° to 7° (and width should not be reduced below 0.010 to 0.012 inch) to reduce rubbing and frictional heat.

Speeds for reaming vary according to type of material being cut. The recommended speed for reaming types 301, 302, 304, 316, 321, 347, 403, and 410 is 20 to 75 surface feet per minute; for 430F, 420F, 416, 440F, and 303, 35 to 100 surface feet per minute. Try various speeds to determine best cutting speeds for individual operations.

Sawing. Blades of hand-held hacksaws for cutting corrosion-resisting steel should be made of high speed steel with approximately 32 teeth per inch for light work and approximately 24 teeth per inch for heavy work. The teeth area should be wavy construction for increasing the width of the cut to prevent binding. To prevent work-hardening, do not allow the blade to drag or ride on the return stroke, especially with the 300 series types. The hacksaw blade should be lightly lubricated with lard oil or other cutting oil for best results.

Use mechanical drive hacksaws for heavy cross-cutting of section bars, tubing, etc. With the power hacksaw, make deeper cuts at relatively low speed. Use the deeper cuts to get under work-hardened surface resulting from the previous cut (stroke). The teeth per inch for saw blades averages 8 to 12, and speed of saw travel usually ranges from 50 to 100 feet per minute, depending on the type and temper of the material being cut. Coolant or lubrication is essential to prevent excess blade damage from heat. The lubrication recommended is soluable oil and water (about one part oil to four parts water) for heavy work. For light work, use a light grade cutting oil.

Band sawing is well suited for low speed straight line or contour sawing of stainless or corrosive-resisting steel within prescribed limitations. Follow the saw manufacturer's recommendations for cutting speed, saw selections, etc. Speeds usually vary with the physical properties, temper, etc., of the type or grade bring cut. As a general guide, speeds range from 100 to 125 feet per minute for material under 0.062 and 60 to 100 feet per minute for thickness over 0.062 inch. Saw blades must be sharp for effective low-speed sawing.

For faster cutting with the band saw, you can use the friction cutting method. In the friction method, the band saw velocity ranges from 5000 feet per minute for cutting flat 1/32 inch material to about 10,000 feet per minute for ½ inch and 14,000 for 1 inch material. Tubing material is run at slightly higher speed. Feed for this material can be considerably higher than is used for slow-speed cutting. Rates range from about 100 feet per minute for light gage to 15 to 18 feet per minute for ½ inch material.

Heavy pressure to maintain cut is not usually necessary. Use just enough pressure to create proper heating and softening at cut point without forcing the saw. Don't use lubricants.

Bending (single curvature). Most steel sheet can be bent, provided that equipment with adequate bending and cutting capacity is available and that the materials are formed in the soft condition or lower temper range. The heat-treatable alloys are usually formed in the annealed condition and heat-treated if required or specified after forming. You will have some difficulty from warping due to heat-treating, and you must be careful when forming the material to prevent sporadic or uneven stress in the work piece. Parts will require jigs or close control during the heating and cooling phase of heat-treatment. For these reasons, heat-treated formed sheet metal parts are seldom used on aerospace craft. Most materials are used in the normalized or annealed condition.

Springback allowances vary according to the type and temper of material being formed. In any case, however, avoid the use of sharp bend radii on parts that are subject to flexing (cycle) or concentrated stresses, due to possible fatigue or stress-corrosion failure.

Check the bend area for strain, grain, or bend cracking. If parts show presence of these, increase the radius by one thickness or more until the difficulty is remedied.

Follow these general rules in handling and forming steel materials:

a. Handle sheet, sheared or sawed strips and blanks with care to prevent cutting your hands and other parts of your body.

b. Sand, file, or polish sheared or cut edges before forming. Remove rough and sharp edges before starting other machining operations in order to reduce hazards in handling.

c. Form material across the grain when possible, using correct or specified bend radii. Also provide bend relief holes in corners when required.

d. Observe load capacity of equipment such as brakes, presses, rolls, drills, shears, etc.

CAUTION: Machines rated for carbon steel must not be used over 60 percent of rated capacity when cutting or forming stainless steel unless approved by responsible technical authority.

e. Make sure tools and equipment are smooth, free of nicks, rust, burrs, and foreign material. In addition, check dies for alignment tolerances.

f. Protect surfaces of material, especially finished sheet, from scratching, foreign particles, etc. You can protect these surfaces with noncorrosive paper, tape, other approved material, and good cleaning procedures.

g. Protect polished sheet material during forming to prevent die tool marking.

CAUTION: Avoid handling parts, especially corrosion-resistant steel, with bare hands after cleaning and heat-treating or passivation, because fingerprints will cause carburization and pitting of the surface when the part is heated.

Shearing. To prevent damage to shear and to assure clean, accurate cuts, clearance between shear blades should be approximately ½₀ of the thickness of the material to be cut. Maintain blades or knives in sharp condition, clean, and free of nicks. Where only one shear is available, you can use a clearance of 0.005 to 0.006 inch for general shearing of sheet stock up to 0.125-inch thick. Avoid excessive blade clearance to prevent work hardening of the cut area, which increases susceptibility to stress corrosion and burring. Apply lubrication such as lightweight engine oil or soap at regular intervals to prevent galling and to clean blades for prolonged shear blade life.

Blanking and punching. Blanking and punching requires close control of die clearance, shearing action of the punch or blanking die. Clearance for blanking and punching should be 5 percent of the thickness and closely controlled for all gages. Maintain punches and dies in clean, sharp condition, and lubricate them by swabbing or spraying the material to be punched with lightweight lube oil to prevent galling and to aid in keeping the punch and die clean.

Forming sheet stock. The corrosion-resisting series, types 301, 302, 304, 410, 430, 431, etc., generally have good forming and drawing qualities. Some types (302, 304, and 305) have forming characteristics superior to plain carbon steel because of the wide spread between tensile and yield strength, and higher elongation. More power is required to form these types than is required for carbon steel because of higher tensile strengths; and their yield strength increases rapidly during forming and bending.

The straight chromium grades, such as 410, 416, 430, and 446, react similarly to carbon steel and are somewhat less ductile than the 300 series stainless steel. The tensile strengths are higher than that of carbon steel and consequently will stand higher loads before rupture. Yield strengths are also higher, which means that more power is required for bending and forming.

The strains set up by severe reductions (above 45 percent with chromium-nickel types and 20 percent with straight-chromium types) should be relieved by annealing immediately after the operation is completed, especially if you are using type 301. If this material is not relieved in 2 to 4 hours, it may crack.

Springback allowance should be about two or three times the amount allowed for carbon steel. (Naturally, it varies according to the type of material being formed.) Sharp radii must be avoided where parts are subjected to flexing or to concentrated stresses which could lead to fatigue or stress-corrosion failure.

Hot-forming. Hot-forming is used to form shapes in stainless steel that cannot be achieved by cold-forming. In using heat for forming, it is important that you control the temperature closely. Fully anneal finished parts to relieve them of residual stress and carbide precipitation which affects corrosion resistance.

Do hot-forming at temperatures somewhat lower than usual hot-forming temperatures. The unstabilized chromium-nickel grades may be formed at temperatures up to 800° F. Avoid the use of higher temperatures in order to prevent carbide precipitation.

The straight chromium (type 400 series) steels are more responsive to hot-forming than the chromium-nickel grades. The reaction of these metals to hot-forming is similar to carbon steels. Upon heating to 800° to 900° F, their tensile strength is lowered considerably and at the same time ductility begins to increase. The air-hardening grades, types 403 and 410, are formed in two temperature ranges:

a. Low temperature forming up to 1400° F. The advantage of forming at this temperature is that parts can be stress-relieved at 1350° to 1450° F. to restore strength uniformity, and scaling is held at a minimum.

b. High temperature forming at 1525° to 1575° F. At this temperature, forming is somewhat easier because strength is low and ductility is higher. Upon completion of forming at this temperature, parts must be fully annealed under controlled conditions by heating to 1550° F. and holding, slowly cooling to 1100° F. (at approximately 50° F. per hour), then cooling in air.

Exercises (225):

1. What type twist drills are used to drill stainless steel?

2. Why should you control the speed of the drill when drilling corrosion-resistant steels?

3. How can the poor heat conduction of stainless steel be overcome when drilling?

4. Why are spiral fluted type reamers preferred over straight fluted reamers when reaming corrosion-resistant steels?

5. Describe the recommended hand-held hacksaw blades used to cut light and heavy sections of stainless steel.

6. What factors affect the amount of springback allowance for bending steel?

7. What results when corrosion-resistant steel is heat-treated after being handled with bare hands?

8. The clearance between the blades on a squaring shear used to cut steels is directly related to what particular feature of the material being cut?

9. Describe the type of area for which sharp bend radii are NOT recommended.

10. What procedures should you follow to prolong the shear blade life when cutting steels on a squaring shear?

2-5. Corrosion Control of Metals

Progress in the manufacture of aircraft metals and advanced techniques of repair and corrosion prevention are keeping pace with advanced research to reduce or prevent corrosion and to increase the useful life of the metals we now have. To give you an idea of the seriousness of the corrosion problem, it has been estimated that the monetary losses sustained by the military services as the result of corrosion amount to several billion dollars a year.

The corrosive destruction or attack on metals involves chemical and physical processes which are evidenced by tarnish, pitting, perforation, or cracking of the metal. The attack varies with the metal and with the physical environment and conditions to which the metal is subjected.

Corrosion recognition and treatment (control) are of major importance to all aircraft maintenance personnel, and to the airframe repairman in particular because corrosion of equipment and primary structure have a great effect on the capability, and on the operational and structural integrity of any weapon system. Corrosion potential and the control of the corroded area pose another challenge for you to recognize and prevent further deterioration of the systems you repair.

Because corrosion can ultimately weaken primary structural members sufficiently to require replacement or reinforcement in order to sustain designed loads, scheduled inspections and preventive maintenance are essential to early detection and correction of corrosion or potential corrosion. If, while you are on a job, you can identify corrosion effects within the area, correction at that time lessens the total amount of labor needed to correct the situation at a later date, and insures that corrosion will not damage a weapon system.

226. Briefly describe what happens when corrosion takes place and point out factors that can cause or prevent corrosion.

Corrosion Defined. Corrosion is the deterioration of a metal by a chemical or electrochemical reaction with its environment. Essentially, all reactions of metals in a gaseous atmosphere (oxygen and water-vapor) or in electrical conducting liquids or electrolytes (commonly aqueous solutions of salts, acids, or bases) are electrochemical reactions. High temperature gaseous corrosion of metals is not generally considered as electrochemical. The corrosion reaction involves the direct union of gas atoms or molecules with the metal (ions) to form oxidation products (oxide in the case of oxygen or chloride in the case of chlorine).

Metals are corroded by the direct reaction of the metal to a chemical. To enable you to better understand the causes and results of the various types of corrosion, let's consider what happens in electrochemical corrosion. Four conditions must exist before electrochemical corrosion can occur. (See fig. 2-14.) Under these conditions there must be something that corrodes—the metal anode; there must be a cause—the cathode; there must be a continuous liquid path—the electrolyte (usually condensate and salt or other contaminations); and there must be a conductor to carry the flow of electrons from the anode to the cathode. This conductor usually makes a metal-to-metal contact (rivets, bolts, welds, etc.).

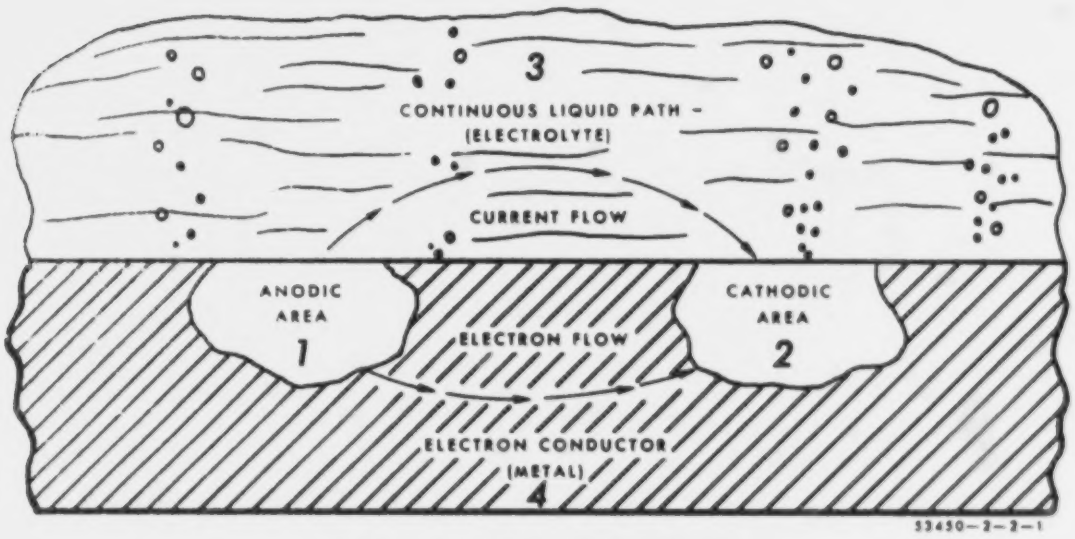


Figure 2-14. Conditions for electrochemical corrosion.

The elimination of any one of the four conditions automatically stops corrosion. For example, an organic film applied to the surface of the metal prevents the electrolyte from connecting the cathode and the anode and the current cannot flow; therefore, no corrosion occurs.

At normal atmospheric temperatures, metals do not corrode appreciably without moisture, but moisture in the air is usually enough to start action. Oxygen is also usually essential for serious corrosion to take place in ordinary water at room temperature. Other factors that cause a metal to corrode are: acidity or alkalinity of the conductive medium (pH factor); stability of the corrosion products; biological organisms, particularly anaerobic bacteria; variation in composition of the corrosive medium; temperature; etc.

The initial rate of corrosion is usually much greater than the rate after a short time, because the oxide film which forms on a metal surface tends to protect the metal underneath. This is not true of stress corrosion.

Corrosion is generally accelerated by rising temperature. An increase in temperature results in increased conductivity of the electrolyte, and in an increased solubility and diffusion rate of normally protective corrosion products. Cathodic depolarization by dissolved oxygen is a process which "cleans off" the cathode, causing it to be more active. This process is increased by an increase in temperature because of more rapid diffusion of oxygen. On the other hand, at over 176° F., the solubility of oxygen in solution becomes very small and the corrosion rate is decreased.

Factors in Corrosion Control. The degree of severity, rate of corrosion, and the causes and types of corrosion depend on many factors. Certain factors cannot be controlled in the field at squadron level and must be accepted. However, when properly performed, preventive maintenance materially reduces the possibility and degree of corrosion. The degree of corrosion depends largely on the effect of five factors:

- Section size.
- Material selection.
- Geographical location and environment.
- Heat-treatment.
- Preventive maintenance.

Effect of section size. Thick structural sections are subject to corrosive attack because of possible variations in their composition, particularly if the sections are heat-treated during fabrication. Similarly, when large sections are machined or chem-milled after heat-treatment, the physical characteristics of thinner sections differ from those of thicker areas. Section size is based on structural requirements and cannot be changed for the purpose of controlling corrosion.

From a maintenance standpoint, the correct approach is one of recognizing the critical nature of the integrity and strength of major structural parts and of maintaining permanent protection over such areas at all times in order to prevent deterioration.

When two dissimilar metals are used and possible contact may develop, remember that if the surface of the more active member of the pair is small compared with the surface of the less active member, corrosive attack will be severe and extensive when insulation breaks down. If the cathode or less active member is small compared to the anode, anodic attack will be superficial or general. For example, an aluminum fastener in contact with a relatively inert titanium structure may corrode severely, while a titanium bracket secured to a large aluminum member would cause only a relatively superficial corrosive attack on the aluminum sheet.

Effect of material selection. One of the fundamental factors in corrosion is the nature of the material. High strength, heat-treatable aluminum and magnesium

alloys are very susceptible to corrosion while titanium and stainless steels are less susceptible in atmosphere environment. Materials must be selected primarily for structural efficiency, however, and corrosion resistance is necessarily a secondary consideration in design. The use of more corrosion-resistant materials in any design normally involves additional weight to achieve the strength. Since weight considerations are a major factor in constructing airframes, particularly in missiles, the primary means of preventing corrosion is proper maintenance procedures.

The use of corrosion-resistant alloys is not a cure-all for corrosion prevention. Corrosion-resistant metals are, by nature, passive and can cause severe galvanic corrosion of less noble neighboring materials. A common mistake is to replace a corroded part with a corrosion-resistant alloy only to find that the corrosion has shifted and increased in severity.

Effect of geographical location and environment. This factor concerns weapons systems exposed to marine atmospheric moisture, tropical temperatures, industrial chemicals, soils, and dust in the atmosphere. This factor naturally is controlled by the requirement for establishing operating bases at specific geographical locations.

Effect of heat-treatment. Proper heat-treatment of metals is a vital factor in establishing its resistance to corrosion. Heat-treatment is used to interlock the molecules or grains of the internal metallic materials in such a way as to resist intermolecular action. Improper heat-treatment results in undesired hardness and makes the material subject to intergranular chemical reaction.

Effect of preventive maintenance. The most vital factor in preventing corrosion, and the one which can be controlled only by field personnel, is the removal of the electrolyte. The term "electrolyte" refers here to contaminating materials (moisture, salt, dirt, grease, fluids, etc.) which come in contact with the metal surfaces. The corrosive effect is determined by the composition of the contamination, the type of metal, and the length of time the materials remain in contact. As explained previously, the extent of attack is almost always inversely proportional to the frequency of cleaning. Thus, the more frequently a surface is cleaned the less the possibility of corrosive attack. Anodic and chemical treatments, as well as proper paint finishes, should be applied in the critical areas to protect aluminum and magnesium alloys. The purpose of these coatings is to provide a barrier to inhibit the action of corrosive environment.

Exercises (226):

1. Describe the four conditions necessary for corrosion to occur.

2. How can corrosion be stopped?

3. What effect has temperature on corrosion?

4. Why are thick structural sections subject to corrosive attack?

5. What is the primary means of preventing corrosion?

6. What happens when you replace a corroded part with a corrosion-resistant alloy part?

7. What results when a piece of metal is improperly heat-treated?

8. Of the four causes of corrosion, which can you, as an airframe repairman, help to eliminate?

227. Describe causes and visible characteristic effects of various types of corrosion, and identify types of corrosion indicated by given descriptions.

Types of Corrosion. Corrosion is cataloged and classified in many ways. For descriptive purposes, the types we discuss fall under these commonly accepted titles: uniform etch, pitting, intergranular, exfoliation, galvanic, stress, and fatigue corrosion.

Uniform etch. Corrosion of metals by uniform chemical attack is the simplest form of corrosion and occurs in the atmosphere or in liquids. It occurs frequently under normal conditions of exposure and is relatively uniform over the metal surface. The surface effect produced by most chemical attacks (as by an acid) is a uniform etching of the metal. On a polished surface, this type of corrosion is first seen as a general dulling of the surface. If it continues, the surface becomes rough and possibly frosted in appearance.

Micro anode and cathode areas are involved; consequently, uniform etch corrosion is localized corrosion occurring consistently and uniformly over the surface of a metal. The rusting of iron, the tarnishing of silver, the fogging of nickel, and the high temperature oxidation of iron or stainless steels are typical examples of uniform etch. The discoloration or general dulling of metals created by exposure to high temperatures is not considered as uniform etch corrosion.

Pitting. This is the most common and severe form of localized corrosive attack on aluminum and magnesium alloys. Thin metal sheets or plates are especially

vulnerable to failure by this form of attack, since penetration of the metal at pit sites results in perforation of the metal, a condition that frequently makes a part unserviceable.

Pitting usually occurs in grain boundaries at highly anodic points on the metal surface. It is primarily the result of localized cell action. Pitting on aluminum alloys is first noticeable as a white or gray powdery deposit, similar to dust, which blotches the surface. When the deposit is cleaned away, tiny pits or holes are seen in the metal surface. Pitting corrosion also appears in other types of metal alloys.

Intergranular. This type corrosion occurs in boundaries between grains or crystals in metals. The boundary areas are usually anodic to the grains. Consequently, in certain corrosive electrolytes, if sufficiently wide potential differences exist between the anodic grain boundaries and the cathodic grains, rapid and concentrated intergranular or intercrystalline corrosion occurs. Many metals are susceptible to some extent to intergranular corrosion; in many cases, this type of attack is of little significance. However, when the corrosion attack at grain boundaries is severe, the strength and other physical properties of the metal may be reduced out of proportion to the amount of metal consumed.

Of the structural alloys, the so-called nonstabilized stainless steels are singularly vulnerable to intergranular corrosion. When these alloys are heated in the temperature range of 900° to 1500° F. for a sufficient time, the carbon contained in the alloy combines with chromium in the alloy to produce an iron chromium carbide which precipitates in the grain boundaries. This results in the lowering of chromium content of areas adjacent to the carbides. The chromium deprived portions of the alloy are susceptible to intergranular corrosive attack.

This increased susceptibility to intergranular corrosion through heating is frequently referred to as "sensitization to intergranular corrosion." If not followed by proper solution annealing treatment, welded nonstabilized stainless steels may be sensitized to grain boundary corrosion attack in the heat-affected zones on either side of the weld.

Exfoliation. Exfoliation is a form of intergranular corrosion and shows itself by "lifting up" the surface grains of a metal by the force of expanding corrosion products occurring at the grain boundaries just below the surface. It is visible evidence of intergranular corrosion and is most often seen on extruded sections where grain thickness is usually less than in rolled forms of metal alloys.

Galvanic. Galvanic corrosion occurs when dissimilar metals are in contact and an external circuit is provided by the presence of a buildup of corrosion at the joint between the metals. For example, aluminum and magnesium skins riveted together in an aircraft wing form a galvanic couple if moisture or contamination are present. Metals grouped together in table 2-1 have no strong tendency to produce galvanic corrosion and are relatively safe to use in contact with each other.

The coupling of metals from different groups and distant from each other in table 2-1 usually results in galvanic corrosion of the metal higher on the list. In table 2-2 the farther apart the metals are, the greater is the galvanic tendency (as can be determined by measurement of the electric potential difference between them.)

All commonly used metals cause corrosion of magnesium in a strong salt environment. Cadmium or zinc plating on the more cathodic metals such as iron and steel greatly reduces galvanic corrosion. It has been found that tin-plated metal, when connected to magnesium, causes less corrosion than cadmium- or

TABLE 2-1
GROUPING OF METALS AND ALLOYS

Group I	Magnesium and its alloys. Aluminum alloys 5052, 5056, 5356, 6061, and 6063.
Group II	Cadmium, Zinc, and Aluminum and their alloys (including the aluminum alloys in Group I).
Group III	Iron, Lead, and Tin and their alloys (except stainless steel).
Group IV	Copper, Chromium, Nickel, Silver, Gold, Platinum, Titanium, Cobalt, and Rhodium and their alloys; Stainless Steel and Graphite.

1. Metals classified in the same group are considered similar to one another.
2. Metals classified in different groups are considered dissimilar to one another.

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TABLE 2-2
GALVANIC SERIES OF METALS AND ALLOYS

Anodic End	Magnesium
	Magnesium Alloys
	Zinc
	Alclad
	Aluminum 6053
	Cadmium
	Aluminum 2024
	Cast Iron
	Wrought Iron
	Mild Steel
	13% Chromium Steel Type 410 (Active)
	18-8-3 Chromium Nickel Stainless Steel Type 316 (Active)
	18-8 Chromium Nickel Stainless Steel Type 304 (Active)
	Tin
	Lead
	Lead Tin Solders
	Naval Brass
	Manganese Bronze
	Muntz Metal
	76 Ni-16 Cr-7 Fe Alloy (Active)
	Nickel (Active)
	Silicon Bronze
	Copper
	Red Brass
	Aluminum Brass
	Admiralty Brass
	Yellow Brass
	76 Ni-16 Cr-7 Fe Alloy (Passive)
	Nickel (Passive)
	Silver Solder
	70-30 Cupro-Nickel
	Monel
	Titanium
	13% Chromium Steel Type 410 (Passive)
	18-8-3 Chromium Nickel Stainless Steel Type 316 (Passive)
	18-8 Chromium Nickel Stainless Steel Type 304 (Passive)
	Silver
	Graphite
	Gold
Cathodic End	Platinum

53430-2-2-739

zinc-plated metal. This happens because, in this unusual circumstance, the tin polarizes and acts as an insulator. This contradicts tables 2-1 and 2-2, so keep in mind that the galvanic series of metals and alloys is to be used for *general* information and that exceptions do exist.

Stress. Stress-corrosion failure results from the combined effect of tensile stress and corrosion. Cold-working or straining, quenching (in heat-treatment), grinding, or welding may produce internal stresses, while applied stress may be local or uniform and static or cyclic. The most destructive type of stress is that which is local and nonuniform. Under such conditions, the stressed zones are subject to accelerated corrosion.

It is known that areas of metals which are subjected to applied stresses develop a more anodic nature at such areas under corrosive conditions. Adjoining unstressed areas or less stressed areas are less anodic or more cathodic.

Stresses induced when a piece is deformed, those induced by press and shrink fits, and those in rivets and bolts are internal stresses. Concealed stress is more important than design stress, because stress corrosion is difficult to recognize before it has overcome the design safety factor.

The magnitude of the stress varies from point to point within the metal. Stresses in the neighborhood of the yield strength are generally necessary to promote stress corrosion cracking; but failures have occurred at lower stresses.

Fatigue. Fatigue corrosion is a special case of stress corrosion caused by the combined effects of cyclic stress and corrosion. No metal is immune to some reduction of its resistance to cyclic stressing if the metal is in a corrosive environment. Damage from fatigue corrosion is greater than the sum of the damage from both cyclic stresses and corrosion.

Fatigue-corrosion failure occurs in two stages. During the first stage, the combined action of corrosion and cyclic stresses damages the metal by pitting and cracking to such a degree that fracture by cyclic stressing will ultimately occur, even if the corrosive environment is completely removed. The second stage is essentially a fatigue stage in which failure proceeds by propagation of the crack and is controlled primarily by stress concentration effects and the physical properties of the metal.

Fracture of a metal part due to fatigue corrosion generally occurs at a stress far below the fatigue limit in laboratory air, even though the amount of corrosion is unbelievably small. For this reason, protection of all parts subject to alternating stress is particularly important, even in environments that are only mildly corrosive.

Exercises (227):

1. A general dulling of a polished surface that has not been exposed to high temperature indicates what type of corrosion?
2. What is the most severe form of localized corrosive attack on aluminum and magnesium alloys?
3. Describe the cause of intergranular corrosion.
4. Visible evidence of intergranular corrosion is referred to as what type of corrosion?
5. How is galvanic corrosion usually recognized?
6. What produces the first stage of fatigue-corrosion failure?

228. Specify typical areas of an aircraft to inspect for corrosion and cite the inspection procedures to follow when inspecting for corrosion.

Without proper and systematically performed inspections and maintenance, corrosion may seriously damage any weapon system. All equipment must be carefully inspected at each scheduled inspection for signs of corrosion. Under extreme conditions of humidity, temperature, and atmospheric conditions due to geographical location, the frequency of corrosion inspections may vary. Materials that require special treatment to safeguard them against corrosion are those most subject to corrosive attack and require more careful inspection and maintenance.

Typical Locations. The first appearance of corrosion on unpainted aluminum surfaces is in the form of deposits or spots, especially around skin seams, lap joints, areas where sand or dirt and grime collect, or in niches and crevices where traces of cleaning compound have accumulated. Pay particular attention to areas where moisture does not evaporate as rapidly as in other locations more directly exposed to sun and air. Areas subjected to battery acids, relief tube spray, smoke, exhaust fumes, and gunfire gases require closer attention and more frequent maintenance.

There is less corrosion on painted, aluminum coated, or aluminum plated surfaces than on unprotected surfaces; however, corrosion will attack protected metals if moisture penetrates the protective coating to the metal surface. If this happens, the affected areas generally have a scaly or blistered appearance, or sometimes a paint discoloration. Corrosion on aluminum, magnesium, and plated steel surfaces can often be recognized by the dulled or pitted appearance of the

area, and sometimes by whitish, greyish, or reddish powdery deposits.

Interior surfaces and lap joints. When you inspect interior surfaces and lap joints, give particular attention to areas where drain holes may become clogged, to fittings and braces, to compound parts inside the aircraft, to sections where foreign matter or moisture may accumulate because of improper drainage or disposal outlets, to structures underneath floor boards, and to faying surfaces. Special inspections must be made of areas where magnesium alloys are used.

Dissimilar metals. Closely inspect areas where dissimilar metals are in contact, since an electric current is generated and flows from one metal to the other. The current causes a chemical action which corrodes one of the metals. Corrosion is accelerated when appreciable moisture is present between dissimilar metals. Leather, neoprene, soundproofing, and insulating materials can pick up and hold moisture, causing corrosion.

Corrosion at spotwelds. Corrosion at spotwelds is chiefly the result of the entrance and entrapment of corrosive agents between the layers of metal. Some of the corrosion may be caused originally by fabrication processes, but its progress to the point of skin bulging and spotweld fracture is the direct result of moisture and contaminant working its way through open gaps and seams. This type of corrosion is first indicated by corrosion products appearing at the crevices through which the corrosive agents enter. Corrosion may appear at other external or internal faying surfaces, but it is usually more prevalent on external areas.

More advanced corrosive attack causes skin buckling and eventual spotweld fracture. Skin buckling in its early stages may be detected by sighting along spotweld seams or by using a straightedge. The only way you can prevent this corrosion and buckling is to keep potential moisture entry points (including gaps, seams, and holes created by broken spotwelds) filled with sealant.

Piano hinges. This type hinge is frequently found on access doors, plates, leading edges, ailerons, trim tabs, etc. Some are actuated only at inspection periods. Regardless of location, inspect this type hinge frequently. Corrosion of piano hinges usually begins in the hinge-pinhole and propagates outside in exfoliation corrosion.

Exhaust gas paths. Exposed areas contaminated by gases are highly susceptible to corrosion. These areas (external, inside nacelles, wing spars, flap wells, attaching angles, etc.) must receive thorough cleaning and inspection at frequent intervals.

Wheel-wells, landing gear, dive brakes, and similar areas. Landing gears are subjected to repeatedly higher stresses than any other part of an aircraft. The above areas are also exposed to mud, water, salt, gravel, and other debris from runways during flight operations. Due to many complicated shapes, assemblies, fittings, and recesses, complete coverage by protective film is difficult. During inspection of these areas pay particular attention to the following trouble spots:

- Magnesium wheels, especially around boltheads, lugs, lockrings, wheel web areas, etc., for entrapped water and foreign materials.
- Exposed tubing, B nuts and ferrules, underclamps and tubing identification tapes, and hose covered with braided wire.
- Crevices between stiffeners, ribs, and lower skin surfaces.
- Exposed position indicator switches, springs, and electrical connectors and equipment.

Heavy or tapered aluminum alloy skin surfaces. Heavy or thick sections of heat-treatable aluminum alloys are susceptible to intergranular corrosion and exfoliation of the metal. When you inspect external skin surfaces, look for metal exfoliation, especially around countersink fastener heads. Exfoliation is first evident as a small raised bump under the surface or paint film.

Inspection Procedures. On occasion you will be called to assist the corrosion control personnel during a corrosion inspection of an aircraft. Each aircraft has four basic areas to be inspected: wings, fuselage exterior, empannage, and fuselage interior. There are many procedures for inspection. One typical procedure is to start at the wing tips. Survey the leading edge of the wing, working from outboard at the tip, inboard to the fuselage, and then inspect the trailing edge, being especially observant of niches or *natural wells,* such as attachment points of control surfaces, flaps, ailerons, spoilers, etc., where foreign matter will collect.

After you have inspected the upper surface, inspect the lower surface of the wing, checking ribs, brackets, and all natural wells. Keep in mind the different forms that corrosion takes from uniform etch to intergranular exfoliation. After you inspect the wings, start at the nose of the aircraft and progressively inspect the areas we previously discussed (wheel wells, spotwelds, fasteners, piano hinges, etc.), to the tail of the aircraft, first working the right side then the left. After the fuselage, inspect the empennage with the same systematic thoroughness as the wings. Being systematic is the key to a complete inspection. Some aircraft inspection workcards are being changed at this time to an incorporated corrosion inspection which is based primarily on this systematic type of inspection.

Once the exterior of the aircraft has been satisfactorily inspected, inspect the internal portion, paying particular attention to rest and relief areas due to the corrosive properties of the materials in these areas. Carefully inspect *well forming* brackets, drain hole areas, bulkheads, and other moisture accumulation areas, and keep in mind the prevention aspect. You can eliminate many major and repetitious repairs by early detection and correction of corrosion through inspection. Inspection and recognition comprise the first stage of corrosion control; but documentation is also a vital part of this procedure.

You already know that specific entries are required on the AFTO Form 781A, Maintenance Discrepancy and Work Document, of the aircraft historical records (AFTO 780 series). When you cannot correct corrosion at the time of inspection of an aircraft, you must make an entry in the aircraft forms. In the symbol block, indicate the seriousness of the discrepancy by either a red X or a red diagonal. If the corrosion is so extensive as to jeopardize the safety of the aircraft (intergranular exfoliation in a main structural member, etc.), and could create a "safety of flight" factor, enter a red X. For minor, correctable corrosion such as etch, pitting, etc. discovered in a noncritical area, enter a red diagonal, the symbol for minor discrepancies not of a safety nature.

After you determine the proper symbol and enter it on the AFTO Form 781A, enter the date the discrepancy was discovered in the date discovered (Date Discd) block. The discrepany block should contain the type of corrosion discovered and the location. Pinpoint the location by the station number. The name of the corroded item, if so identifiable, should also be given. For example: "galvanic corrosion on rib, right wing, station 623, 7 inches aft of rear spar." When you finish entering the discrepancy clearly and completely, put your first name initial, last name, and rank in the Discovered By block.

As an airframe repairman, part of your assigned duties may be to inspect a weapon system or equipment for evidence of corrosion. If the inspection reveals evidence of corrosion in any area, removal of the corrosion and application of preventives is a must.

The degree to which you will be involved in corrosion removal and treatment depends on the directives and SOPs of your assigned base and unit and on the availability of qualified personnel, equipment, and materials necessary for the task.

TO 1-1-2, *Corrosion Control and Treatment for Aerospace Equipment,* contains detailed information on removal procedures and application of preventives for the various types of metals used in the manufacture of aircraft. Methods, materials, and equipment used in preventive maintenance painting are also discussed in this technical order.

Because of the detailed explanation found in TO 1-1-2, methods, procedures, equipment, and materials used for corrosion removal and treatment are not discussed in this volume. Once the inspection for corrosion determines necessity for removal and treatment, follow the instructions outlined in the technical order.

When your inspection locates corrosion so severe that it necessitates the removal of the damaged component or part, follow repair procedures as outlined in the specific -3 technical order for the aircraft.

Exercises (228):

1. What characteristic is common to the areas of an aircraft that are most likely to produce a corrosive situation?
2. What are the signs of corrosion at spotwelds?
3. Briefly state the procedure for inspecting a wing for corrosion.
4. When inspecting piano hinges, where would you first check for evidence of corrosion?
5. Beside inspecting and recognizing corrosion, what other factor is considered important in corrosion control?
6. What technical order contains detailed information on corrosion treatment?

229. Explain the working practices, you, as an airframe repairman, can follow to prevent corrosion during repairs of aircraft metals.

In previous objectives, we discussed corrosion prevention from the standpoint of the causes, types, and inspection procedures. But preventing corrosion from getting started is the best approach to the problem. And using the proper techniques in our repair and fabrication of repair parts will greatly reduce the chances of corrosion.

Typical Aircraft Repair Protection. We have been told time and time again "Don't scratch the metal," but we know from experience that no matter how careful we are, the metal does get scratched, unfortunately. What do we do after the metal is scratched—throw it away? Hardly. We must economically use the metal, and with proper treatment, it can be used.

During fabrication and repair of aircraft metals there are several basic procedures you must follow. Selection of the correct material composition, working practices, and application of corrosion preventatives are the ones we'll discuss at point. Later in the course, we will cover specific repairs and repair procedures.

Material composition. In the process of making repairs, keep in mind the compositions of similar metals and alloys when making substitutions in materials to fabricate a repair. Galvanic corrosion occurs when dissimilar metals are in contact and an external electrolytic circuit is created which results in a buildup of corrosion at the joint between the metals. For example, aluminum and magnesium skins riveted

together in an aircraft wing form a galvanic couple if moisture and contaminations are present. When aluminum pieces are attached with steel bolts or screws, galvanic corrosion can occur between the aluminum and the steel.

The use of aluminum alloys containing magnesium, such as 5052 and 5053, usually reduces galvanic corrosion of the magnesium alloys and also reduces simultaneous corrosion of the aluminum. Under severe exposure, when the contact of magnesium alloys and plated steel bolts is necessary, the use of 5052 aluminum washers may prevent severe galvanic attack.

Continuity of the liquid path may also be broken by the use of vinyl or polyester tapes. When conditions favorable to galvanic corrosion are unavoidable, always protect both portions of a couple.

When practical, use rivets, bolts, and other fasteners made of the same material as the main structure. When that is not practical, select such fasteners from materials lower in Table 2, in order to distribute the anodic attack over the larger surface area of the two coupled metals. This is particularly important where the fasteners are subjected to high stress and where the safety factor is low. However, the structural strength of the aircraft must not be endangered by substituting incorrect parts. Refer to the specific technical order (the -3 TO) for the aircraft involved or to the prime support systems manager for repairs not specifically authorized.

Working practices. The working practices we are concerned with here are those which prevent scratches, because scratches can lead to corrosion and possibly fatigue failure if the part you're fabricating is highly stressed or subjected to repeated small stress reversals. Regardless of the metal, you must take precautions to reduce the amount of fabrication defects. The metal that presents the greatest problem is alclad aluminum, with its soft outer surface of pure aluminum.

Aluminum must be protected from surface scratches during all fabrication operations, such as forming, cutting, etc. Draw layout lines with a pencil. Draw only cut lines with a scriber. In the case of titanium, however, *never* draw layout lines with a carbon marking agent (such as pencil). Carbon combines with titanium at high temperature and weakens the material, which in turn leads to cracks along the layout line. Use vise jaw protectors or some suitable substitute when filing any metal.

The proper storage of metal is half the battle in reducing scratches on metal. Technical Order 00-85A-23-1, *Preservation, Packaging and Storage,* states that the clad surface on aluminum provides adequate protection against corrosion if the material is kept dry; therefore, a contact preservative (oiling) is not required. But you *must* protect the clad surfaces against scratches or abrasion, since damage will permit corrosion of the alloyed metals under the clad coating. To protect clad surfaces against this type damage, put a sheet of minimum 15-pound basis weight paper between each two sheets of metal.

Bare (nonclad) surfaces of aluminum alloy are less resistant to corrosion, and therefore require coating of all surfaces, including the edges, with a thin, even coat of oil to impede corrosion attack.

Store all aluminum alloy sheets in dry, fully enclosed spaces, and do not expose them to weather and other corrosion-inducing conditions which render the material unusable. If aluminum is wet when delivered, dry it thoroughly, either in still air or by dry air currents. Once it's safely dried, store the metal, but do not store it near such obvious sources of moisture as steam or water pipes, and store it far enough from open doors and windows to reduce the possibility of moisture. Be sure to keep stored aluminum away from such chemicals as caustics, nitrates, phosphates, and acids.

In the continuous use of large quantities of metal, use the oldest stock first. Occasional checking and rotation of stock eliminates any serious corrosion problems which may develop.

The storage procedures outlined for aluminum are similar for the other metals used in an airframe shop. In storage, keep metals separate from other metals of different composition (steels, aluminums, titanium, and magnesium).

Application of corrosion preventives. After you fabricate the repair parts, and before installing them, apply a protective coating of a corrosion preventative. Any time you fasten two pieces of aluminum alloy together, even though they are of the same composition, apply coatings of zinc chromate primer on the contacting faying (joining) surfaces. Remove all metal chips, such as those which might be caused by drilling operations, to allow for close fit of the materials and to prevent scratching. After drilling holes in the parts to be assembled, apply zinc chromate on the inner and the outer surfaces to insure that all contacting surfaces—metal, rivets, bolts, washers, etc.—have the corrosion protection needed.

In the case of magnesium, practice the following:

a. For magnesium to magnesium contact, give all faying surfaces one or more coats of zinc chromate primer.

b. For contact between magnesium and dissimilar metals, use moisture-proof films to protect both magnesium and the dissimilar metal, use only those dissimilar metals that are compatible with magnesium, separate the metals so that any corroding medium cannot complete an electrical circuit, and protect the magnesium.

c. For magnesium in contact with absorptive materials (wood, paper, etc.), seal the absorptive materials with paint, varnish, wax, latex, epoxy, or similar coatings, and then treat the magnesium faying surface with zinc chromate primer, as with magnesium to magnesium contact.

Exercises (229):

1. Why are aluminum alloys 5052 and 5053 usually used with magnesium alloys?

2. What is the authority for the material composition of repair fasteners?

3. Cite work practices that will reduce scratches on the surface of alclad aluminum.

4. Why can you *not* use a pencil to mark titanium?

5. How should you store clad aluminum sheets in a metal rack?

6. When should you use zinc chromate primer on aluminum?

7. Under what condition is a moisture-proof film recommended when working with magnesium alloys?

230. Analyze the factors used in the substitution of metals.

In selecting interchangeable or substitute materials for the repair and maintenance of aircraft, it is of the utmost importance to check the appropriate technical orders when specified materials are not in stock or obtainable from another source. It is impossible to determine that another material is as strong as the original by mere observation.

There are four requirements that you must keep clearly in mind in this selection. The first and most important of these is maintaining the original strength of the structure. The other three are: maintaining contour or aerodynamic smoothness; maintaining original weight, if possible, or keeping the added weight to a minimum; and maintaining the original corrosive-resistant properties of the metal.

You can appreciate the importance of checking the specific technical order if you understand that different manufacturers design structural members to meet various load requirements for specific aircraft. Structural repair of these members, apparently similar in construction, thus varies in their load-carrying design with different aircraft.

Structural repair instructions (including tables of interchangeability and substitution for ferrous and nonferrous metals, and their specifications for all types of aircraft used by the Air Force) are normally prepared by the aircraft contractor. Such instructions are usually compiled in two separate series of handbooks and manuals. These are the 1-1A series of handbooks, known as *General Engineering Manuals*, and the -3 technical order of the basic handbook covering structural repair instructions for specific models of aircraft.

In this volume, of course, we cannot cover all of the interchangeability or substitutions authorized for specific aircraft; you must use your appropriate -3 technical order for this. Instead, we cover the general requirements of substitution and substitution factors.

Substitution Factors. As we mentioned previously, strength, contour, weight, and corrosion resistance are of primary concern in selecting substitute material. We cannot select or substitute metals based on thickness, composition, or tensile strength factors only. However, there are some general rules that will make selection of metals easier to understand.

Strength. There are two basic rules which apply when substitution of material is necessary.

Rule 1. The substitute material must provide cross-sectional strength in tension, compression, shear, and bearing at least equal to that of the original material.

Rule 2. Never substitute a material thinner than the original or with a cross-sectional area less than the original.

The explanation for rule 1 is that most parts in an aircraft structure carry a tension, compression, shear, and bearing load at some time during the operation of the aircraft. The magnitude of these loads is seldom known when repairs are made. Therefore, the tensile, compression, shear, and bearing strengths of a part made of a substitute material must be at least equal to those of the original part.

Strict adherence to rule 1 leads to the following paradox: If in one application 2024-T4 is substituted for 2024-T6 and if in another application 2024-T6 is substituted for 2024-T4, a substitute thicker than the original must be used in either application. This seeming inconsistency, which occurs with other combinations of metals, is explained by the following comparison of mechanical properties:

	2024-T4 (bare)	*2024-T6 (clad)*
Ultimate tensile strength	62,000 pounds per square inch	60,000 pounds per square inch
Compressive yield strength	40,000 pounds per square inch	47,000 pounds per square inch

If 2024-T4 is substituted for 2024-T6, the substitute material must be thicker unless the reduction in compressive strength is known to be acceptable. On the other hand, if 2024-T6 is substituted for 2024-T4, the material must be thicker unless the reduction in tensile strength is known to be acceptable.

The explanation for rule 2 is that the buckling and torsional strengths of many sheet metal and tubular

parts depend primarily upon the thickness rather than the allowable compressive and shear strengths of the material. Therefore, a substitute that is thinner than the original reduces the buckling and torsional strengths of a part considerably even though the thinner substitute material has higher allowable compressive and shear strengths.

Contour. Maintaining the contour of the original structure means that the flow of air over the completed repair will not create drag on the aircraft or change the flight characteristics due to a vortex or drag condition that you have created by your repair. It also means that the repair will include bends and angles incorporated in the original structure. During the substitution of metals, you must be extremely careful, especially during flush repairs, to insure that the material used can do the required job without creating new problems.

If the strength cannot be maintained by using the original thickness of material, do not increase the strength at the sacrifice of smoothness. Rather, find some other method. In some instances, for example, you can maintain strength by increasing doubler or backing plate thickness.

Weight. Depending on the particular aircraft and the position of the repair on that particular aircraft, added weight can become a problem at times. Weight control is secondary in some cases, but it can become a primary problem. A control surface that requires balancing is an example of added weight being a major concern during repair. The weight of the substitute material should corespond to the original as closely as possible.

Extrusion Substitution. We have previously discussed extrusion, how it is formed, and its composition. On some occasions, the damage you encounter in your work may include the extruded shapes used in the structure of the aircraft.

In the event of damaged extrusion, you must determine the proper replacement of the piece and, if it's not available, you have to find (or figure) the dimensions and forming angles of authorized substitutions that can be formed from sheet rock. Table 2-3 shows a typical page of a technical order that you would use to determine the substitute material, metal thickness, and proper forming angles. For example, if the repair figure in the -3 technical order identifies the extrusion to be numbered AND10136-2404, the material to be used in the repair is identified in the extrusion table as 7075-T6 aluminum alloy with a base (marked A) 2.500 inches wide and a leg (marked B) 1.625 inches wide. The thickness of the base (marked T1) is .094 inch and the leg is also .094-inch thick. All radii on the extrusion (marked R) are ⅛ inch or 0.125. If the extrusion of the same composition and dimensions can be obtained, use it to make the necessary repair in compliance with the -3 technical order.

Many occasions arise when such extrusion is not available and must be fabricated from flat sheet stock. Using the equivalent side of table 2-3, you need to find the extrusion number for substitute dimensions. In this example, the extrusion number is AND10136-2404. The material to be formed is 7075-0 aluminum alloy (7075 in the annealed condition). The dimensions of the base and leg remains the same as the original with a base 2.500 inches wide and a leg of 1.625. (Note that in the repair sample, three pieces are needed to replace the extruded original.) In the replacement part, T1 includes the T1 and T2 of the original part. Make T1 0.071 inches thick and T2 0.071 inches thick. The radius of the angles changes from 0.125 on the original extrusion to 0.160 inch on the substitute material to allow for the bending of the sheet stock with a bending brake.

After forming and dressing the substitute pieces, you must heat-treat the material to give it the strength needed to carry the stresses involved. Note at the top of table 2-3 that you heat-treat the material to the -T condition. In this particular case, you must bring it to the -T6 condition, the same as the original extrusion.

Thickness Substitution. Previously, we discussed the necessity for maintaining the original strength of substitute materials. Table 2-4 is an extract from TO 1-1A-9, showing the solution of substitution between aluminum alloy sheet stock.

The following guidelines apply to the use of table 2-4.

a. Locate the horizontal row containing the symbol of the material to be replaced.

b. Locate the vertical column containing the symbol of the substitute material.

c. To obtain the thickness of the substitute material, multiply the thickness of the material to be replaced by the factor at the intersection of the row and column found by the first and second steps, respectively.

For example, to find the thickness of clad 2024-T6 that is to replace clad 7075-T6 of 0.032-inch thickness:

- Clad 7075-T6 is in the second horizontal row of factors.
- The substitute clad 2024-T6 is in the eighth vertical column of factors.
- The required factor is 1.32; 1.32 × 0.032 is equal to 0.042 inches. The minimum thickness of the substitute clad 2024-T6 is 0.042-inch material.

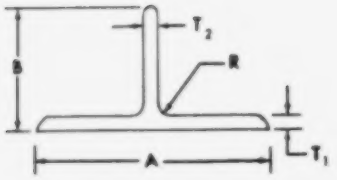
Exercises (230):

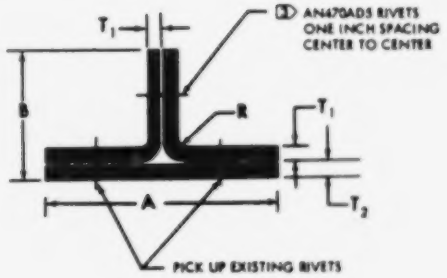
1. Which factor is the most important in selecting a substitute metal?

2. Why is it necessary to check the specific technical order (-3) before selecting a substitute metal?

3. Resistance to buckling and torsional strengths of many sheet metal and tubular parts depend mainly on what physical property?

TABLE 2-3
SUBSTITUTE REPAIR MATERIAL





Notes

1. ALL DIMENSIONS ARE IN INCHES.
2. AFTER FORMING, HEAT TREAT O MATERIAL TO T CONDITION PER SPECIFICATION MIL-H-6088.
3. USE AN470D6 RIVETS WHEN THICKNESS (T) IS .080 OR LARGER.

EXTRUDED TEES (SYMMETRICAL)

EXTRUSION NUMBER	DIE NUMBER	MAT'L: AL. AL.	A	B	T_1	T_2	R
AND10136-1601		2024-T4 7075-T6	1.750	.875	.094	.094	.125
AND10136-1605		2024-T4	1.750	1.375	.094	.094	.125
AND10136-1706		2024-T4	1.875	1.500	.094	.094	.125
AND10136-2001		7075-T6	2.000	1.000	.078	.078	.125
AND10136-2002		7075-T6	2.000	1.000	.094	.094	.125
AND10136-2004		7075-T6	2.000	1.250	.078	.078	.125
AND10136-2005		7075-T6	2.000	1.250	.094	.094	.125
AND10136-2006		7075-T6	2.000	1.250	.125	.125	.125
AND10136-2007		7075-T6	2.000	1.750	.094	.094	.125
AND10136-3401		7075-T6	2.500	1.250	.094	.094	.125
AND10136-3402		7075-T6	2.500	1.250	.125	.125	.125
AND10136-3404		7075-T6	2.500	1.625	.094	.094	.125
AND10136-3405		7075-T6	2.500	1.625	.125	.125	.125
AND10136-3406		7075-T6	2.500	1.625	.156	.156	.125
AND10136-3408		2024-T4	2.500	2.000	.156	.156	.125
AND10136-3001		7075-T6	3.000	1.500	.125	.125	.125
AND10136-3004		7075-T6	3.000	2.000	.188	.188	.188
AND10136-3005		2024-T4	3.000	2.500	.125	.125	.125
NAS344-43		2024-T4	1.750	1.125	.078	.078	.125
NAS344-44		7075-T6	1.750	1.375	.078	.078	.125
NAS344-69		7075-T6	3.000	1.500	.188	.188	.125
NAS344-78		7075-T6	3.500	2.875	.250	.250	.188
1M317	ALC15281	2024-T4	2.500	1.500	.070	.093	.125
1M349	ALC23320	2024-T4	3.500	.875	.064	.064	.094
1M358	ALC22899	7075-T6	1.875	1.000	.080	.080	.090
1M368	ALC13482	7075-T6	2.500	2.437	.094	.094	.187
1M2141	ALC61862	2024-T4	2.000	2.440	.094	.094	.125
1M3109	ALC57341	2024-T4	1.750	2.250	.100	.170	.094
1M3115	ALC57369	7075-T6	2.000	2.900	.100	.160	.125
1M3139	HAR15657	2024-T4	2.100	2.500	.170	.090	.125
1M3154	ALC57973	7075-T6	2.340	1.340	.081	.081	.125
1M3164	ALC61128	2024-T4 7075-T6	2.130	2.130	.063	.063	.125
1M3165	ALC61127	7075-T6	2.380	1.250	.063	.063	.125
1M3184	ALC61384	7075-T6	3.500	3.250	.100	.160	.125
1M3193	ALC66017	7075-T6	4.000	1.500	.094	.094	.125
1M3194	ALC59956	7075-T6	2.800	2.300	.078	.078	.130
1M3218	ALC61798	7075-T6	3.500	1.250	.063	.063	.125
1M3229	HAR16982	7075-T6	3.130	1.000	.072	.072	.094
1M3255	HAR17129	7075-T6	3.800	.675	.125	.125	.125
1M3261	ALC36847	7075-T6	2.360	2.250	.095	.064	.130
1M3272	ALC66030	7075-T6	3.880	2.125	.094	.094	.125
1M3276	HAR17367	7075-T6	1.900	1.900	.094	.100	.125
1M3278	HAR17362	7075-T6	2.830	.750	.125	.066	.125
1M3345	REY9769	7075-T6	3.400	1.430	.150	.125	.125
1M3433	REY11297	7075-T6	3.900	.675	.180	.125	.125
1M3436	REY11298	7075-T6	2.560	1.155	.173	.125	.125
1M3441	HAR3441	7075-T6	2.060	.900	.063	.063	.125
1M3476	HAR21908	7075-T6	3.800	.750	.156	.080	.130

SHEET METAL EQUIVALENTS

EXTRUSION NUMBER	MAT'L: ALCLAD	A	B	T_1	T_2	R
AND10136-1601	2024-O 7075-O	1.750	.875	.071	.071	.13
AND10136-1605	2024-O	1.750	1.375	.071	.071	.13
AND10136-1706	2024-O	1.875	1.500	.071	.071	.13
AND10136-2001	7075-O	2.000	1.000	.063	.063	.13
AND10136-2002	7075-O	2.000	1.000	.071	.071	.16
AND10136-2004	7075-O	2.000	1.250	.063	.063	.13
AND10136-2005	7075-O	2.000	1.250	.071	.071	.16
AND10136-2006	7075-O	2.000	1.750	.100	.100	.22
AND10136-2007	7075-O	2.000	1.750	.071	.071	.16
AND10136-3401	7075-O	2.500	1.250	.071	.071	.16
AND10136-3402	7075-O	2.500	1.250	.100	.100	.22
AND10136-3404	7075-O	2.500	1.625	.071	.071	.16
AND10136-3405	7075-O	2.500	1.625	.100	.100	.22
AND10136-3406	7075-O	2.500	1.625	.125	.125	.28
AND10136-3408	2024-O	2.500	2.000	.125	.125	.19
AND10136-3001	7075-O	3.000	1.500	.100	.100	.22
AND10136-3004	7075-O	3.000	2.000	.160	.160	.28
AND10136-3005	2024-O	3.000	2.500	.100	.100	.16
NAS344-43	2024-O	1.750	1.125	.063	.063	.13
NAS344-44	7075-O	1.750	1.375	.063	.063	.13
NAS344-69	7075-O	3.000	1.500	.160	.160	.28
NAS344-78	7075-O	3.500	2.875	.190	.190	.44
1M317	2024-O	2.500	1.500	.071	.080	.13
1M349	2024-O	3.500	.875	.080	.080	.09
1M358	7075-O	1.875	1.000	.040	.040	.09
1M368	7075-O	2.500	2.437	.071	.071	.16
1M2141	2024-O	2.000	2.440	.071	.071	.13
1M3109	2024-O	1.750	2.250	.125	.071	.19
1M3115	7075-O	2.000	2.900	.125	.071	.28
1M3139	2024-O	2.100	2.500	.071	.190	.13
1M3154	7075-O	2.340	1.340	.063	.063	.13
1M3164	2024-O 7075-O	2.130	2.130	.080	.080	.13
1M3165	7075-O	2.380	1.250	.080	.080	.13
1M3184	7075-O	3.500	3.250	.125	.071	.28
1M3193	7075-O	4.000	1.500	.071	.071	.16
1M3194	7075-O	2.800	2.300	.063	.063	.13
1M3218	7075-O	3.500	1.250	.080	.080	.13
1M3229	7075-O	3.130	1.000	.063	.063	.13
1M3255	7075-O	3.800	.675	.100	.100	.22
1M3261	7075-O	2.360	2.250	.080	.090	.13
1M3272	7075-O	3.880	2.125	.071	.071	.16
1M3276	7075-O	1.900	1.900	.080	.071	.19
1M3278	7075-O	2.830	.750	.063	.125	.13
1M3345	7075-O	3.400	1.430	.100	.125	.28
1M3433	7075-O	2.900	.675	.100	.190	.44
1M3436	7075-O	2.560	1.155	.100	.190	.44
1M3441	7075-O	2.060	.900	.080	.080	.13
1M3476	7075-O	3.800	.750	.080	.160	.28

TABLE 2-4

ALUMINUM ALLOY SUBSTITUTION AND CONVERSION TABLE FOR COMMERCIAL TEMPER DESIGNATIONS

Material to be Replaced	New Or Substitute Material															
	7075 -T6	Clad 7075 -T6	Clad 2024 -T86	Clad 2024 -T84	Clad 2024 -T81	2024 -T36	Clad 2024 -T36	Clad 2024 -T6	2024 -T4	Clad 2024 -T4	6061 -T6	Clad 2014 -T6	Clad 2014 -T4	5052 -H38	5052 -H36	5052 -H34
7075-T6		1.08	1.07	1.08	1.22	1.37	1.46	1.43	1.68	1.81	1.92	2.04	2.10	2.10	2.40	2.92
Clad 7075-T6	1.00		1.00	1.00	1.13	1.27	1.35	1.32	1.55	1.68	1.77	1.88	1.94	1.94	2.22	2.70
Clad 2024-T86	1.00	1.00		1.02	1.15	1.29	1.37	1.34	1.58	1.71	1.80	1.91	1.96	1.96	2.26	2.74
Clad 2024-T84	1.00	1.00	1.00		1.13	1.27	1.35	1.32	1.55	1.68	1.77	1.88	1.94	1.94	2.22	2.70
Clad 2024-T81	1.00	1.00	1.00	1.00		1.13	1.20	1.17	1.38	1.49	1.57	1.67	1.72	1.72	1.97	2.40
2024-T36	1.00	1.00	1.00	1.00	1.00		1.07	1.05	1.18	1.33	1.40	1.49	1.53	1.53	1.75	2.14
Clad 2024-T36	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.15	1.25	1.32	1.40	1.44	1.44	1.65	2.00
Clad 2024-T6	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.18	1.27	1.35	1.43	1.47	1.47	1.68	2.05
2024-T4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.08	1.15	1.22	1.25	1.25	1.43	1.74
Clad 2024-T4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.06	1.12	1.16	1.16	1.32	1.61
6061-T6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.06	1.10	1.10	1.15	1.53
R301, Clad 2014 -T6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.03	1.03	1.18	1.44
R301, Clad 2014 -T4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.15	1.39
5052-H38	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.15	1.39
5052-H36	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.22
5052-H34	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

4. During flush repairs, if the strength cannot be maintained by using the original thickness of material, how can you insure that the required strength is maintained?

5. When does the problem of weight control, in making repairs, have to be monitored very closely, and why?

6. What must the final temper be of the material used to repair a section of extrusion numbered AND-10136-2408?

7. What three factors must you know about the material being replaced before you can accurately use the conversion table shown in the text as table 2-4?

Basic Handtools

HANDTOOLS ARE the airframe repairman's best friend. Without them, an airframe repairman is as helpless as he would be without his eyes. Regardless of the type of job to be done, an airframe repairman must have, choose, and use the correct tools in order to do the work quickly, properly, and accurately. Without the proper tools and the knowledge of how to use them, you waste time, cut efficiency, and may injure yourself. This chapter explains the specific purposes, correct use and proper care of the common handtools, measuring and layout tools, and hand cutting tools you use.

3-1. Turning Tools

231. Specify the type of pliers to use in a given work situation and point out factors related to the care and use of pliers.

Types of Pliers. Pliers consist of a pair of forged metal bars resembling scissors, with jaws at one end. A screw or pivot holds the jaws together at the proper angle. Pliers are used for gripping, bending, forming or holding work and, in some cases, for cutting. The size of pliers indicates their overall length, usually ranging from 5 to 12 inches. The better grades of pliers are drop forged steel. Pliers are available with serrated and flat jaws. Those used most frequently in airframe repair work are shown in figure 3-1.

Flatnose pliers. Flatnose pliers are very satisfactory for making flanges. The jaws are square, fairly deep, and usually well matched. The hinge is firm. These characteristics give a sharp, neat bend.

Flatnose side-cutting pliers. Flatnose side-cutting pliers are used to bend or form metal into various shapes and to work in limited spaces. These pliers are equipped with sidecutters for cutting wire and metal and are available in different sizes.

Roundnose pliers. These pliers are used to crimp metal. The jaws are often wrapped to prevent scarring the metal. They are not designed for heavy work, as too much pressure will spring the jaws.

Half-roundnose pliers. These pliers have half-round jaws of varying lengths. They are used to hold objects and make adjustments in tight places.

Diagonal cutting pliers. These pliers, usually referred to as diagonals or dikes, are short-jawed cutters with a blade set at a slight angle on each jaw. This tool can be used to cut wire, rivets, small screws, small bolts, and cotter pins. It is also a good tool to use for removing safety wire.

Clamp pliers. Clamp pliers are used for bending sheet metal and locking templates to blank sheets. They are also used for holding metal for welding. The pliers lock the work with a powerful grip and keep it from slipping. The grip can be adjusted for different thicknesses of metal by turning the screw located in the end of the handle.

Slipjoint combination pliers. Combination slip-joint pliers have serrated (grooved) jaws. The screw or pivot with which the jaws are fastened together may be moved in a small slot so the jaws can open to two widths. To spread the jaws, spread the handles as far apart as possible. Push the slipjoint or pivot to the end of the slot that gives the desired size jaw opening, and close the handles to hold it there. The pivot will not slide in the slot unless the handles are wide open. These adjustable combination pliers are used principally for holding and bending flat or round stock.

Care of Pliers. When not in use, clean the pliers, oil them lightly, and store them in the toolbox where their jaws cannot be damaged by striking hard objects. Never use pliers on hard metal because this will damage the jaw serrations. Keep the pin or bolt at the hinge just tight enough to hold the two parts of the pliers in contact. Never use pliers to turn nuts or screwdrivers, since this will dull the jaw serrations and damage the items being turned.

When the serration on the jaws of these pliers become dull, the pliers no longer grip satisfactorily. To restore the gripping power, grind the serrations on a V-shaped grinding wheel, or file them with a triangular taper file (fig. 3-2). When filing or grinding remove the least material possible from the serrations. If you use the grinder, be careful not to overheat the plier jaw, causing loss of temper. Dip it in cool water frequently while grinding.

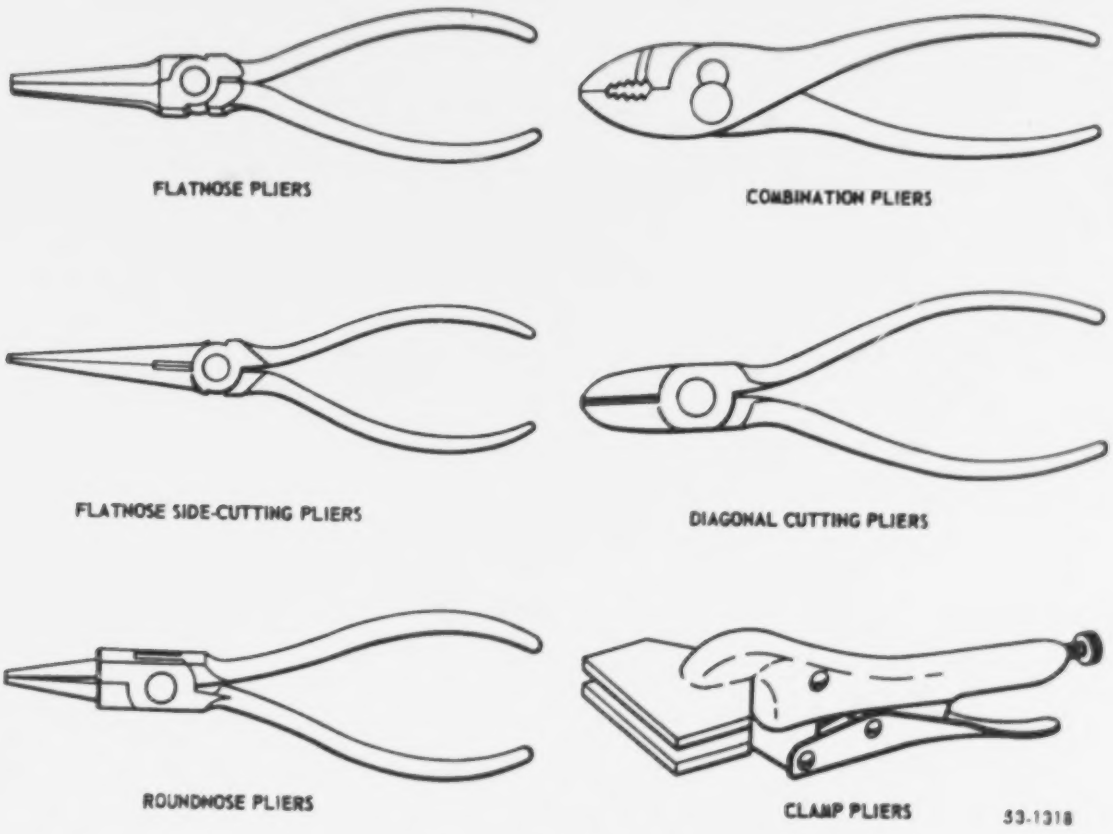


Figure 3-1. Types of pliers.

Exercises (231):

1. Which type of pliers would you select to hold material when drilling?
2. Adjustments made in tight places can best be accomplished by which type of pliers?
3. Why are flatnose pliers satisfactory for making flanges?
4. Why are combination pliers well suited for holding roll stock?
5. What are the results when pliers are used to turn nuts and screwdrivers?
6. What is the main precaution to observe when grinding new serrations on pliers?

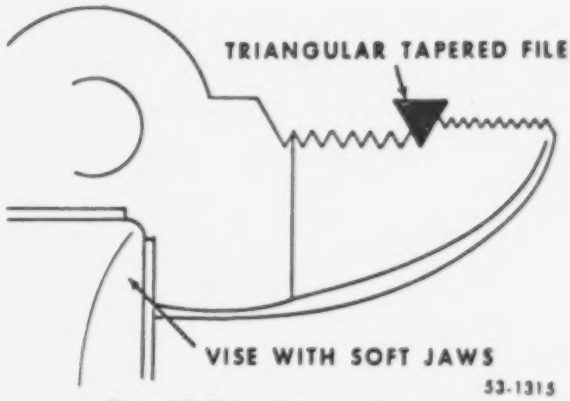


Figure 3-2. Filing plier's jaw serrations.

232. Identify the correct type of wrench for a particular task.

Wrenches. Wrenches are available in a number of types, sizes, and designs. They are used to exert a twist force on nuts, bolts, and screws, with some of them made to grip round stock, rings, couplings and other special objects. One of the most widely used metals for making wrenches is chrome-vanadium steel, which makes them almost unbreakable. The wrenches most commonly used by an airframe repairman are illustrated in figure 3-3.

Open-end wrenches. These wrenches have solid, nonadjustable, open, parallel jaws on one or both ends. They are usually in sets of 6 to 12 wrenches having a series of jaw sizes ranging from 5/16 to 1 inch. Some have jaws parallel to the handle or at an angle up to 90°; most are set at an angle of 15°. Basically, the wrench is designed, to fit a nut, bolthead, stud, or other object, which makes it possible to exert a turning action force for loosening, tightening, or removing an item.

Box-end wrenches. These wrenches are popular tools because of their usefulness in close-quarter areas of work. They are called box-end wrenches because

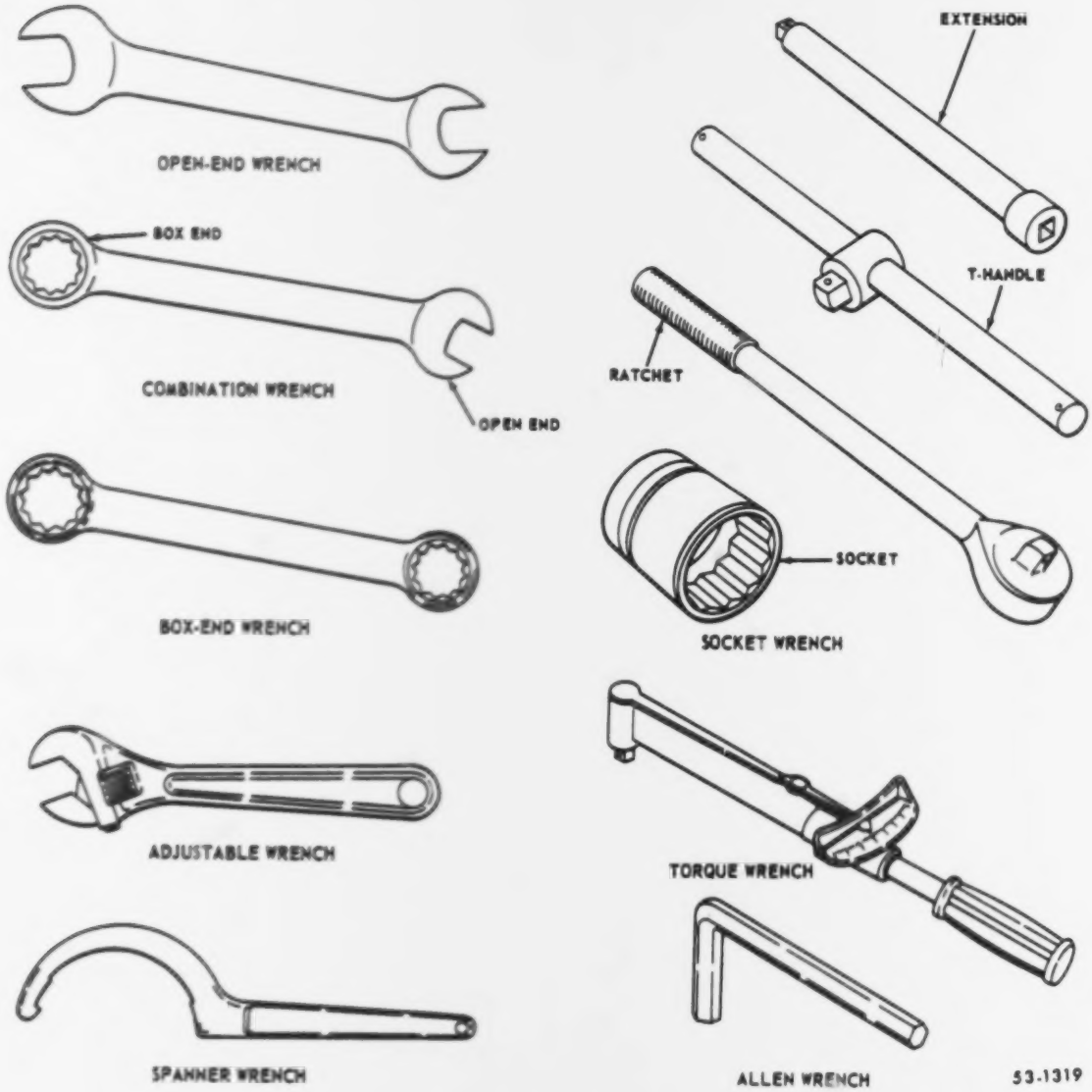


Figure 3-3. Types of wrenches.

they box or completely surround the nut or object concerned. Practically all box-end wrenches are made with 12 points so that you can use a 15° pull or swing in close working areas.

Combination wrenches. These wrenches have one box end and one open end. When a nut or item is broken loose, it can be removed more quickly with an open-end wrench than with a box-end wrench; the open-end can be positioned and removed quicker during the process.

Socket wrenches. These wrenches are made up in two parts: the socket, which is placed over the object to be removed or installed, and the handle which fits into the socket. Several types of handles, extensions, ratchets, and other attachments are available to make it possible to use socket wrenches in almost any location or position. Sockets are made with either fixed or detachable handles. The design of the sockets speeds up the turning process.

Adjustable wrenches. These wrenches come in several sizes, usually determined by the length of the handle. One jaw is fixed, but the other jaw can be positioned as needed by means of a thumb screw or spiral screw-worm adjustment in the handle. The width of the jaw opening can vary from 0 to 1/2 inch or more. The jaws are smooth and are designed like the jaws of the open-end wrench. The angle of the opening to the handle is usually 22 1/2°. These features enable the adjustable wrench to do the work of several open-end wrenches. Although versatile, they are not intended to replace the standard open-end, box-end, or socket wrenches. When using any adjustable wrench, always exert pull on the side of the handle attached to the fixed jaw of the wrench, as shown in figure 3-4.

If a nut or bolt is hard to turn, first put a little thin oil (penetrating oil) around it so that the oil works down into the threads. If this does not loosen it, try tapping the adjustable wrench very close to its jaws with a mallet or plastic-faced hammer (not a metal hammer).

Special wrenches. Special wrenches are for special jobs. Coming within this category are the spanner, torque, and allen wrenches, of which there are numerous types. The *hook spanner*, which has a series of notches cut in its outer edge, is for a round nut. The hook or lug is placed in one of these notches with the handle pointing in the direction the nut is to be turned. Some hook spanner wrenches are adjustable and fit nuts of various diameters.

A *torque wrench* may be intended for use with sockets or have a fixed end for only one unit size. Torque is described as a twisting or turning force that tends to produce rotation. A torque wrench indicates just how much of that twisting or turning force is being applied. On some makes, a pointer on a scale shows the amount of applied force; on others, the dial can be set for the exact amount of torque wanted. Use the torque wrench *only in the final stages of tightening* a nut or bolt. Torque wrenches may be calibrated in inch-pounds or foot-pounds.

Allen wrenches are used to tighten or loosen setscrews or capscrews with recessed heads. The L-shape of the wrench enables you to use it for either a short or long reach. Allen wrenches are not designed for high torque. The small wrenches will snap and the large ones will twist out of shape if you apply excessive torque. If a setscrew is difficult to remove, use penetrating fluid to help loosen it.

Care of Wrenches. Always use a wrench that fits the job. Do not try to increase the leverage of a wrench by placing a pipe over the handle, because this can damage both the work and the wrench.

Cleaning and oiling. Wash the dirt and grease from wrenches with a solvent and wipe them dry with a clean cloth, oiling lightly for storage. Chips can be cleaned from jaw serrations with a file card's soft-metal pin or with a flattened iron wire. Apply a few drops of oil to the moving parts occasionally to keep them working freely.

Repairing Serrations. Jaw serrations on a wrench can be renewed with a fine triangular taper file. Deepen the low points between the teeth with the file, taking care to remove no more material than necessary. If some of the top edges of the teeth are filed off during this operation, use a flat file to file the jaw faces flat, so they are parallel; then file the serrations to the required sharpness.

Repairing work spring. If prolonged use of the adjustable wrench causes the worm spring to become weakened so there is too much play in the jaw, make the adjustment shown in figure 3-5.

Exercises (232):

1. What type of wrench is useful in close-quarter areas?

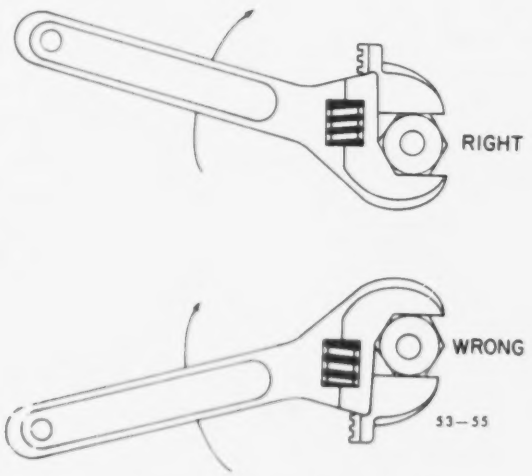


Figure 3-4. Using the adjustable wrench.

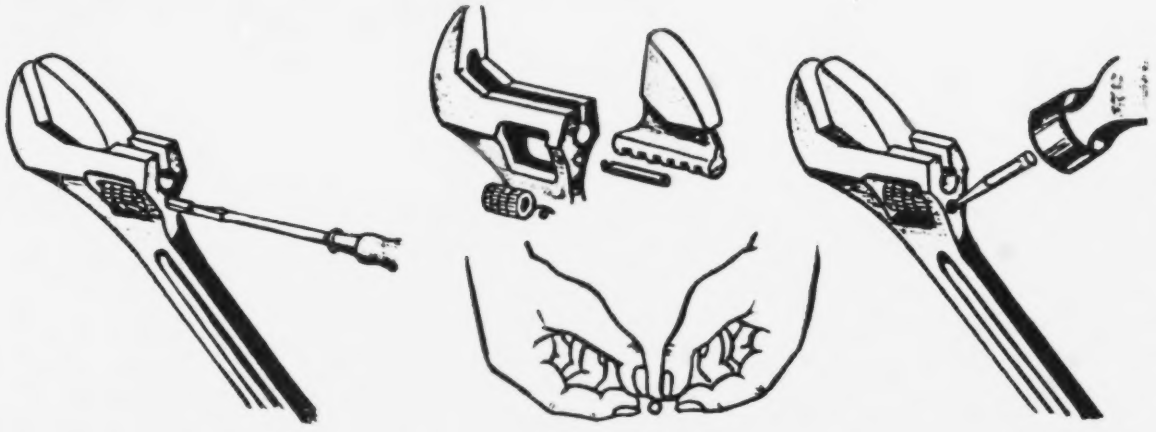


Figure 3-5. Removing the play from an adjustable wrench.

2. For rapid removal of nuts in an open area, which type wrench gives the best results?

3. What type of wrench would you use to remove a round nut?

4. If you had a number of nuts to remove of different sizes, which wrench would you select?

5. What must you remember when using wrenches?

6. How can dirt and grease be removed from wrenches?

233. Differentiate between the types of screwdrivers and state procedures for the proper use and care of screwdrivers.

Types of Screwdrivers. The screwdriver, classified by its blade length and design, is made for loosening or tightening screws or screwhead bolts. It should not be used as a prybar or chisel. The parts of a screwdriver are the handle, shank, and blade, and the sizes of these parts are in proportion to the overall length. There are five types of screwdrivers: standard, phillips, reed and prince, offset, and ratcher (fig. 3-6).

Standard screwdriver. The standard screwdriver, shown in figure 3-6, is the most popular screwdriver. Most standard screwdrivers range from 3 to 12 inches in length, although they may be obtained in shorter and longer lengths. The length is measured from the tip of the blade to the tip of the handle. It is important to select the correct size screwdriver so that the thickness of the blade fits properly into the screw slot.

Phillips screwdriver. The phillips screwdriver is made with a specially shaped blade that fits phillips cross-slot screws. The heads of these screws have a 4-way slot that prevents the screwdriver from slipping. Three standard sizes of phillips screwdrivers handle a wide range of screw sizes. A standard screwdriver should not be used on phillips-head screws.

Reed and prince screwdriver. The reed and prince screwdriver is similar to the phillips screwdriver; however, they should not be confused, as the tip is different. These screwdrivers are manufactured in 3- to 8-inch sizes.

Offset screwdriver. The offset screwdriver is designed to be used in tight places where an ordinary screwdriver cannot be used. It is somewhat unhandy to use, as it is difficult to keep enough pressure on it to prevent slipping. The blades at either end are placed at right angles to each other. They are set in this manner so you can turn a screw a quarter turn, change ends of the screwdriver, and then make another quarter turn.

Ratchet screwdriver. The ratchet screwdriver, sometimes called the spiral screwdriver. This screwdriver is used to drive or remove screw rapidly. Different types of screwdriver bits are used with this type screwdriver.

Care of Screwdrivers. The hardened tips of screwdrivers will withstand much normal wear without necessity for repairs. To preserve the usefulness of

this tool, do not use it for any purpose except to drive screws and special slotted bolts.

Grinding the tip. If a straight or flared tip on a screwdriver becomes nicked or otherwise damaged, it should be reground to its original shape before further damage ruins it. The tip faces must be reground so they are approximately parallel at the tip, to keep the tool from lifting out of the screw slot when in use. The end of the tip must be square, at a right angle to the face, and the sides should be alike in shape and angle as shown in figure 3-7.

To grind the screwdriver, first thin the tip slightly by holding each face to the wheel. Then hold the working edge of the tip squarely on the wheel until nicks are removed and the end is squared up. Make the tip's sides alike by grinding on the face of the wheel. Be sure to dip the tip in water frequently, between short periods of grinding, to keep from overheating it. Do not take off any more material than absolutely necessary.

Since repairing the tip of the phillips screwdriver normally requires special holding fixtures, don't try to shape it by grinding. Using the grinder on this tool without proper fixtures can result in loss of the original angles and bevels, throwing it out of balance so it is unsafe to use.

Handle repair. Since it is difficult to secure a handle on the screwdriver shank, a broken handle usually is not replaced. Handles with roughened or slightly mushroomed heads can be smoothed out with a wood rasp and sandpaper.

Correct Use and Safety Precautions. The following are common everyday working practices you should follow:

a. Keep the point of the screwdriver properly ground.

b. Keep the point free of grease or oil.

c. Use a screwdriver of the proper size with a point that fits the slot in the screw; otherwise, the point of the screwdriver may break or slip, multilating the screw slot or the work.

d. Don't hold the work in your hand while tightening or loosening a screw. If the blade slips, it can give you a bad cut. It is better to put the work in a vise or on a solid surface that will bear the pressure of the screwdriver.

e. Don't use a screwdriver as a chisel.

f. Don't strike the handle with a hammer.

g. Don't use a screwdriver for prying purposes.

When a screw is hard to remove, first try to tighten it by a slight turn clockwise. Then turn the screwdriver counterclockwise and keep tightening and loosening the screw alternately until it turns freely for removal. Stubborn screws can be turned by using an adjustable, open end, wrench. Be sure the wrench fits the tip of the screwdriver snugly against the flat surfaces of the tip.

Exercises (233):

1. How does a standard screwdriver differ from a phillips screwdriver?
2. In what way does a phillips screwdriver differ from a reed and prince screwdriver?
3. When would you use an offset screwdriver?
4. What type of screwdriver has interchangeable tips?

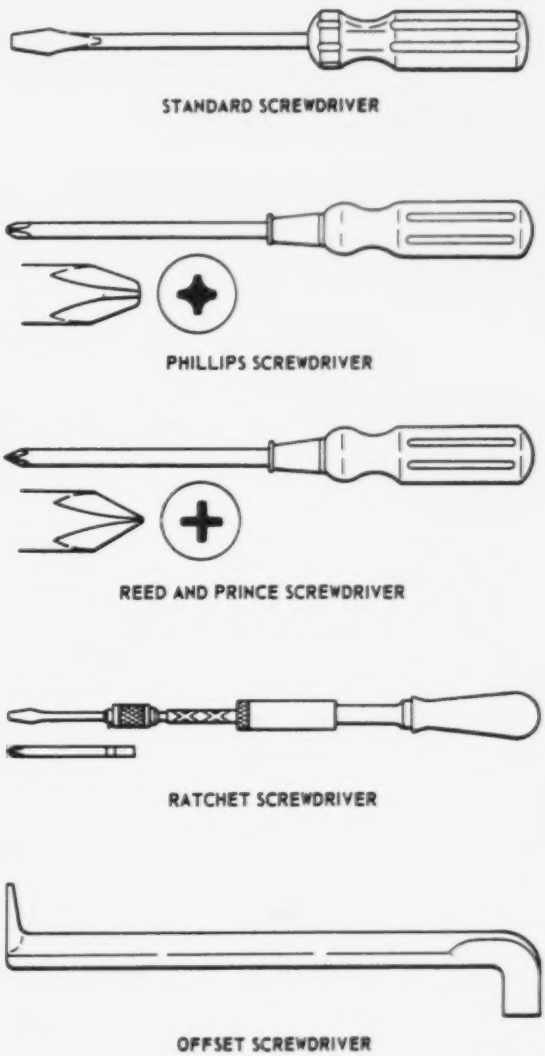


Figure 3-6. Types of screwdrivers.

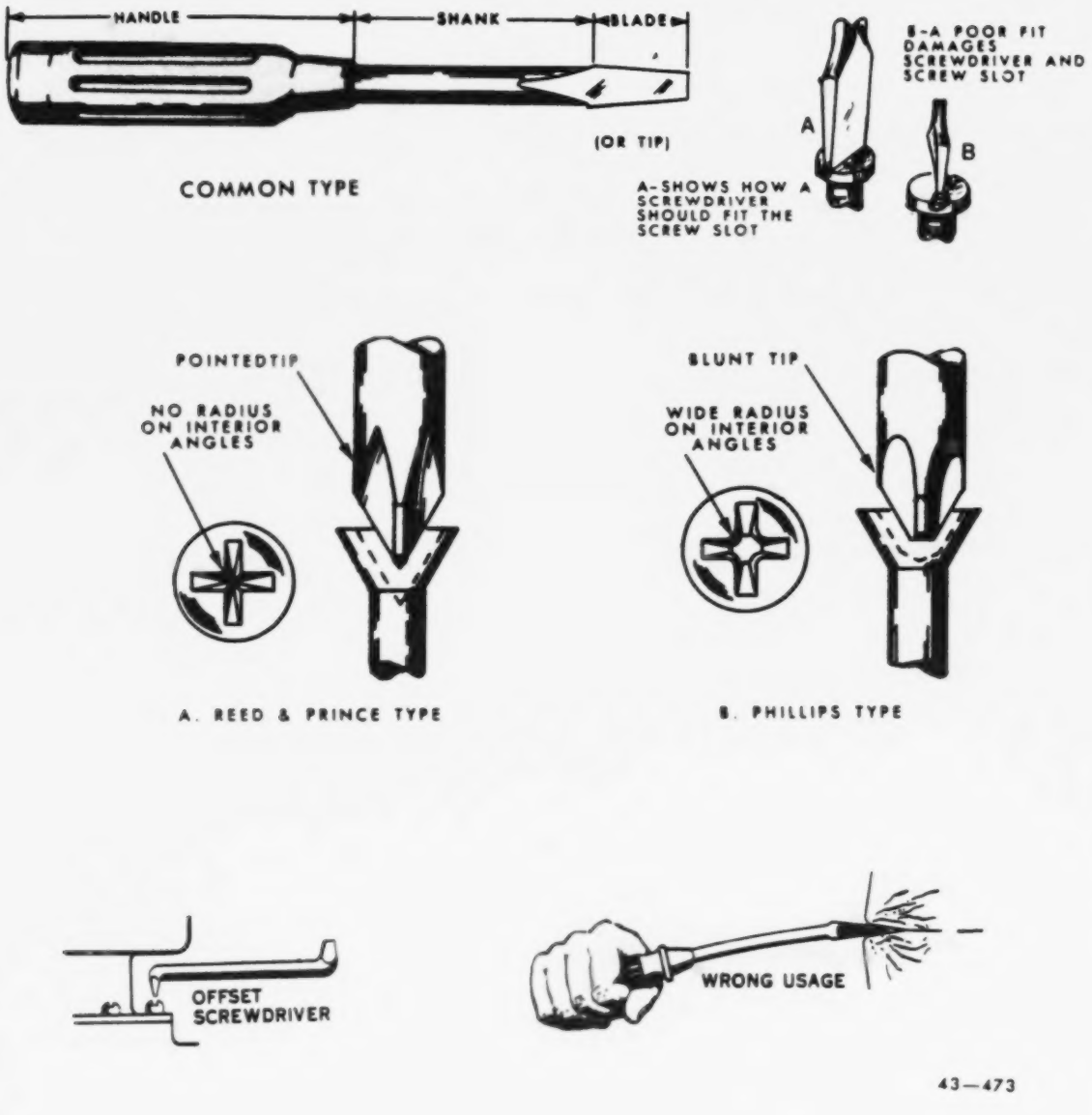


Figure 3-7. Shapes of screwdriver blades and tips.

5. How can you apply extra turning force when using a screwdriver?

6. Describe the procedures for removing hard to turn screws.

7. What is likely to result when an improper size screwdriver is used?

8. How should screws be removed and tightened in work projects that can be hand-held?

9. Why shouldn't reed and prince screwdrivers be reground?

3-2. Hammering Tools

234. Name the type of hammering tool to use for specified tasks, or a type of task for which a given tool is used.

Hammers. Sheet metalworking hammers are made of metal. They are used for riveting, setting, stretching, and planishing, and are classified by usage. Figure 3-8 depicts the various hammers used by an airframe repairman.

Riveting hammer. Riveting hammers are for driving rivets and light chiseling. One end of the hammer head is crosspeened (crosspointed), and the other may have either a square or a chamfered face. Sizes range from 5/8 to 1/8 inch, measured across the face.

Setting hammer. Setting or peening hammers resemble riveting hammers except in the shape of the peen (the pointed end). These hammers are used for

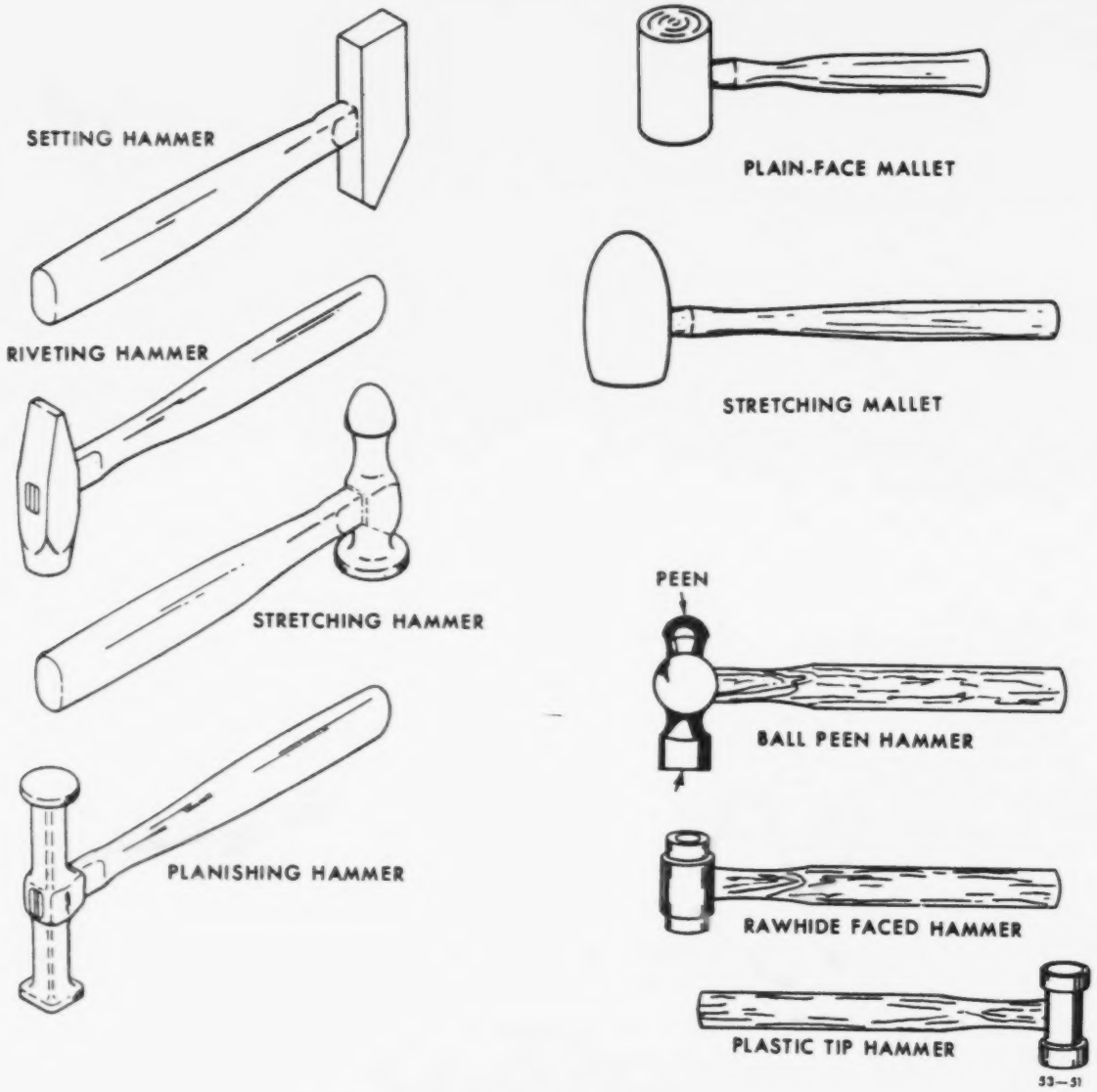


Figure 3-8. Types of hammers.

setting down, clinching, or tucking in the edges of sheet metal. They are particularly useful for double-seaming lids and bottoms and for making seams and elbows. Setting hammers are made with either square faces or chamfered faces. Chamfered face types are preferred.

Stretching hammer. Stretching hammers, also called raising hammers, are for making small depressions or forming concave and convex shapes in soft and semisoft sheet metal. They are available in weights ranging from 20 to 90 ounces.

Planishing hammer. Planishing hammers have metal heads with slightly convex faces. They are lighter than stretching hammers, and are used primarily to smooth (or planish) the surface of parts which have already been formed. In many cases, the flatface wooden, plastic, or rawhide mallet is used for planishing. In planishing, place the metal on a smooth surface, such as a forming block or stake, and lightly strike the irregularities with the face of the hammer.

Mallets. Mallets are made of hardwood, rubber, plastic, or rawhide; they may be classified as plain-faced and stretching. They are generally used for pounding down seams or forming sheet metal over forms or stakes. Since they do not dent or mar the metal as steel hammers do, they are often used for finishing.

Plain-faced mallets are all-purpose mallets. They are usually made of hardwood or rawhide and both faces are plain. During the forming process, they are best suited for planishing—that is, for finishing or removing the remaining small dents and crimps. Stretching mallets may be made of plastic, hardwood, or hard rubber. The bellshaped, the round, and the crosspeen ends are for stretching (or for shrinking), and the plain-faced ends are for planishing. The bell-shaped and round-faced mallets are handy for bumping aluminum into form blocks or on a sandbag. Always keep the faces of hammers and mallets smooth and free of dents to prevent marring the metal while working on it.

Care and Use. Use the 8-ounce ballpeen hammer in layout work for striking prick punches and center punches, for peening and riveting, and for performing other light-duty work. Use the 16-ounce peen for heavy-duty work. When you must protect the surface of the work, use the plastic tip and rawhide-faced mallets.

The handle of any hammer is a very important part of it. Do not *chock* or hold the handle too close to the head, because this reduces the force of the blow and makes it difficult to hold the handle level when the head makes contact with the work. The handle must also be the right size for the proper balance and swing. Without balance and proper swing, the head does not contact the work flatly and you cannot consistently strike the same spot twice.

Most accidents involving hammers are caused by loose heads. Notice in figure 3-9 how the head is secured to the handle. Always check the head for security when you take a hammer from your toolbox. As you can see in figure 3-9, the eye (hold) in the hammerhead is oval-shaped with a bell mouth at either end. The end of the hammer handle is tapered to fit the eye. The handle is driven into the eye far enough to wedge it at the rear of the eye and a steel wedge is driven into the end of the handle to spread the wood and wedge it at the front of the eye, thus preventing the head from slipping in either direction. Usually, you can eliminate any slight tendency of the head to slip in either direction by driving the steel wedge a little farther in the end of the handle.

It is good practice to occasionally grind the face of the hammer lightly to keep it flat and perpendicular to the centerline of the head. Actually, the face should be slightly convex. Grind off any burrs that form around the edge of the face.

Exercises (234):

1. What type and size of hammer do you use to center-punch holes for drilling?

2. When should you use a plastic tip or rawhide-faced mallet?

3. What are you most likely doing when using a setting hammer?

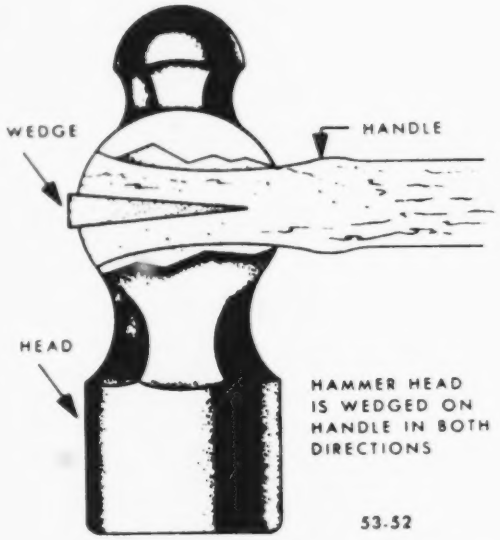


Figure 3-9. Securing hammer and hammer head on handle.

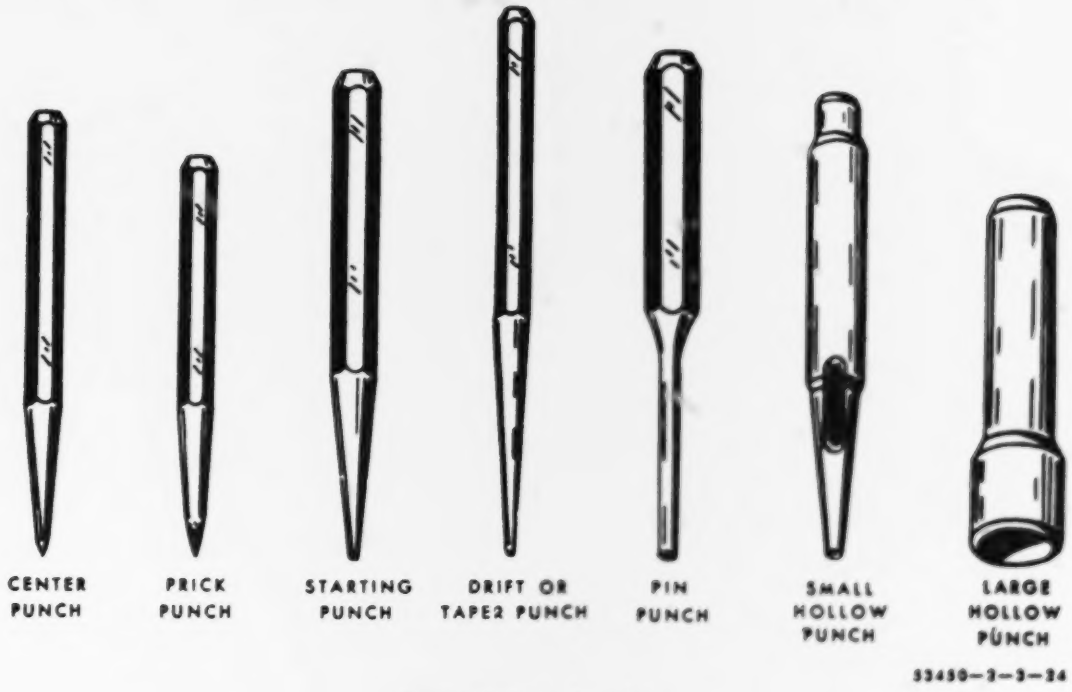


Figure 3-10. Types of punches.

4. If you had to form concave shapes in soft metal, which type of hammer would you use for best results?

5. For finishing purposes, what type of hammering tools are selected?

235. Given a work situation, name the correct hand punch to use.

Hand Punches. You will use several types of punches in airframe repair work, including those for marking metal before drilling, for removing pins and rivets, for aligning holes, and for piercing holes. Each punch is designed for a specific job. Hand punches driven with a hammer include the center punch, prick punch, starting drift punch, drift punch, pin punch, and hollow punch.

There are many types of hand punches you can use; however, the punches illustrated in figure 3-10 are used more often than others.

Center punch. The center punch is used to make a small depression on metal prior to drilling or punching. The depression prevents the twist drill from "walking" during the drilling operation. The punch should never be struck with such force as to dimple the material around the indentation or to cause the metal to protrude through the other side of the sheet. A center punch has a heavier body than a prick punch and is ground to a point with an angle of about 60°.

Prick punch. The prick punch is used to establish location points when laying out patterns on sheet stock. This punch is often used to transfer dimensions from a paper pattern directly to the metal. To do this, first place the paper pattern directly on the metal. Then go over the outline of the pattern with your prick punch, tapping it lightly with a small hammer and making slight indentations on the metal at the major points on the drawing. These indentations can then be used as reference marks for cutting or folding the metal. A prick punch should never be struck a heavy blow with a hammer because it may bend the punch or cause excessive damage to the material being worked.

Starting punch. The starting punch is tapered for strength, has a blunt tip, and is used to loosen tight-fitting pins that are to be removed from a hole.

Drift punch. A drift punch (taper punch) is also used to loosen tight-fitting pins, although its slender taper is not as strong as that of the starting punch. The drift punch is often used to align holes in two pieces of metal before installing screws, bolts, or rivets.

Pin punch. The pin punch has no taper; it is used to drive out rivets which have had the heads drilled off and to drive pins out of holes too deep for the starting punch or drift punch.

In general practice, a pin or bolt which is to be driven out is usually started and driven out with a drive punch until the sides of the punch touch the side of the hole. A pin punch is then used to drive the pin or bolt the rest of the way out of the hole. Stubborn pins may be started by placing a thin piece of scrap copper, brass, or aluminum directly against the pin and then striking it with a heavy hammer until the pin begins to move. Never use a prick punch or center punch to remove objects from holes, because the point of the punch will spread the object and cause it to bind even more.

Transfer punch. The transfer punch is usually about 4 inches long and has a point tapered and then turned straight for a short distance in order to fit a drill locating hole of a template. The tip of the transfer punch has a point similar to that of a prick punch. As its name implies, the transfer punch is used to transfer the location of holes through the template or pattern to the material.

Hollow punch. Hollow punches, with a suitable backup material, are used to pierce holes in thin sheet stock.

Exercises (235):

1. Select the correct hand punch to use by matching the hand punch to a given work situation. A space is provided in front of the work situation to record your selection.
   - _____ a. Helpful in transfer layout locations from paper layouts to metal layout.
   - _____ b. An aid in drilling and punching holes.
   - _____ c. Remove rivet shanks from drilled holes.
   - _____ d. Loosen tight-fitting pins.
   - _____ e. Often used for alignment purposes.
   - _____ f. Indicate the locations of drill holes on sheet stock.
   - _____ g. Punch holes in thin sheet stock.

3-3. Layout and Measuring Tools

Layout and measuring tools are precision design tools, carefully machined and accurately marked. Some are made up of very delicate parts. Exercise care when using them to avoid bending, dropping, or otherwise causing them damage which would impair their performance. The outcome of the job depends upon the accuracy of measurements and layout you make, so it is important to fully understand how to read, use, and care for these tools.

236. List particular types of layout and measurement tools to use for given tasks.

Rule. Rules provided for your use are made of steel and are either rigid or flexible, Do not bend the flexible steel rule intentionally, as it may be broken easily.

In aircraft metalwork the unit of measure most commonly used is the inch. The inch may be divided into smaller parts by means of either common or decimal fraction divisions. The fractional divisions for an inch were determined by dividing the inch into equal parts, then continuing to divide each part—halves (1/2), quarters (1/4), eighths (1/8), sixteenths (1/16), thirty-seconds (1/32), and sixty-fourths, (1/64)—as shown in figure 3-11. Fractions of an inch may be expressed in decimals, called decimal equivalents of an inch; for example, 1/8 inch is expressed as 0.125 (one hundred twenty-five one-thousandths of an inch). Rules are manufactured in two basic types: (1) those divided or marked in common fractions (fig. 3-11) and (2) those divided or marked in decimals or divisions of one one-hundredths of an inch.

A rule may be used either as a measuring tool or as a straight-edge. To measure a piece of stock, place the rule flat across the surface or distance to be measured, holding or steadying the work. To measure the length of a line, lay the rule alongside the line, with the end of the rule at one end of the line, and read the graduation of the rule that is opposite the other end of the line. Figure 3-12 illustrates how a steel rule can be used to take measurements. Care for the rule by wiping it with light machine oil and carefully storing it in a separate compartment of the tool box to protect it from rust, scratches, and other damage.

Tapes. There are several kinds and lengths of tapes, but the most commonly used is 6 feet long and made of flexible steel, coiled in a circular case as shown in figure 3-11. It is graduated on one side in divisions of 1/2, 1/4, 1/16, and 1/32 inch. A small lip on the extending end is used to steady the tape while measuring. The tape will bend, but it should not be bent intentionally, as it may be broken easily.

Scriber. The scriber is designed to serve the airframe repairman in the same way a pencil or pen serves a writer. In general, it is used to scribe or mark cut lines on metal surfaces. The scriber illustrated in figure 3-13, is made of tool steel, 4 to 12 inches long, and has two needlepointed ends. One end is bent at a 90° angle for reaching and marking through holes.

Before using a scriber, always inspect the points for sharpness. Be sure the steel rule being used as a straightedge is flat on the metal and in position for scribing. Tilt the scriber slightly in the direction toward which it will be moved, holding it like a pencil. Keep the scriber's point close to the guiding edge of the steel rule. The scribed line should be heavy enough to be visible, but no deeper than necessary to serve its purpose.

Dividers. Dividers are used for measuring distances between two points, for transferring or comparing measurements directly from a rule, or for scribing an arc, radius, or circle. Figure 3-14 illustrates two types

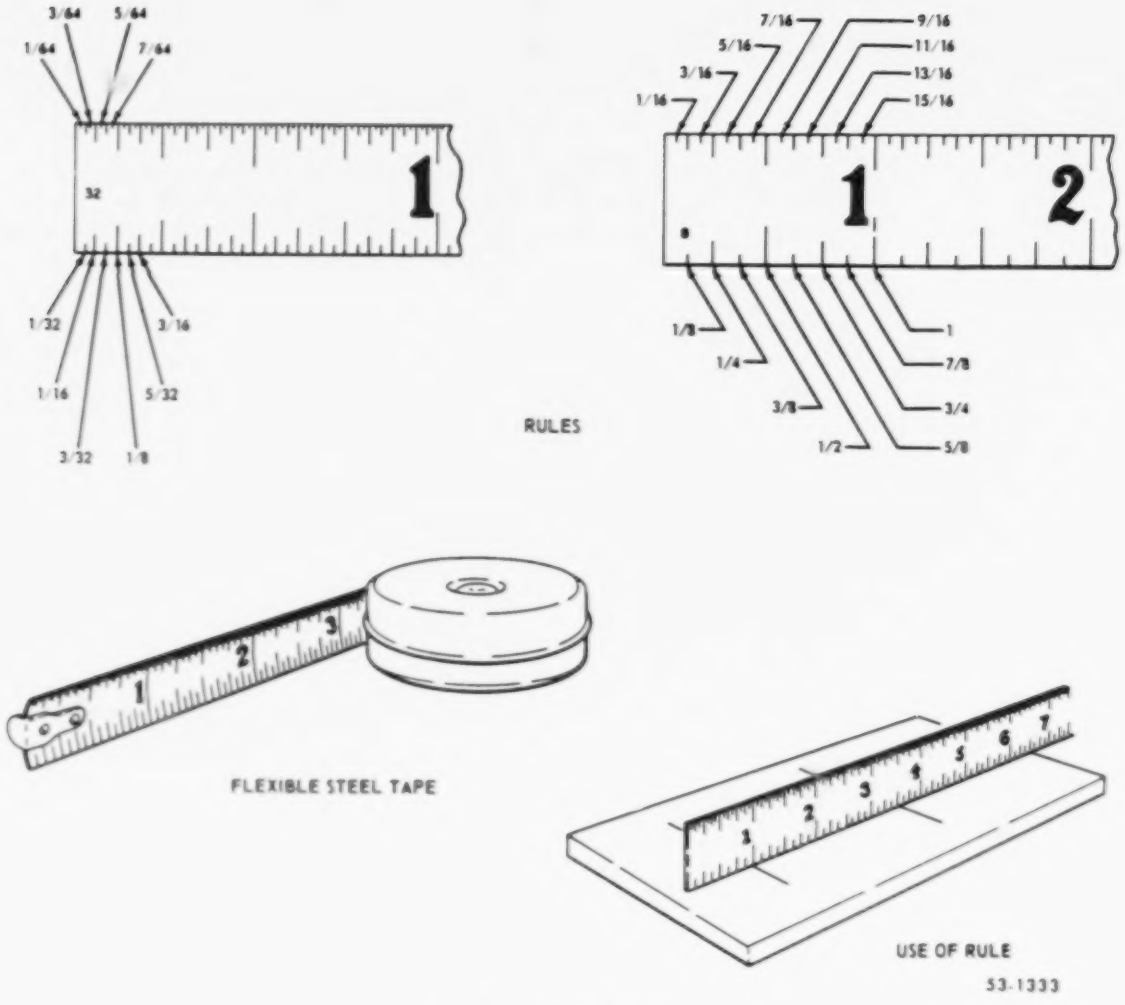


Figure 3-11. Rules and tapes.

of dividers: the spring type and wing type. The spring divider consists of two sharp points at the end of straight legs, held apart by a spring and adjusted by means of a screw and nut. The spring divider is available in sizes from 3 to 10 inches in length. The wing divider has a steel bar that separates the legs, a locking nut for securing a rough measurement, and an adjusting screw for fine adjustments. The wing divider is available in 6-, 8-, and 12-inch lengths. An improved version of the wing divider has the tip of one leg removable so that a pencil can be inserted.

To set the dividers, hold them so that one leg is at a determined mark on the material or rule, turn the adjustment nut, and bring the other leg to rest on material or rule at point of required measurement.

To draw an arc or circle with a divider, hold the top with your thumb and forefinger, position one leg on determined mark on the material, and with pressure exerted on both legs, swing (or rotate) the dividers in a clockwise direction and draw the desired arc or circle. Offset the tendency of the legs to slip by inclining the dividers in the direction in which they are being rotated. In working on metals, use the dividers only to scribe arcs or circles that are later to be removed by cutting. Draw all other arcs or circles with pencil compasses to avoid scratching the material. (See fig. 3-15.) On paper layouts, use the pencil compasses for describing arcs and circles. Use dividers to transfer measurements because they are more accurate.

Combination Set. The combination set, as shown in figure 3-16, is a tool that has several uses. The set is comprised of a 12-inch grooved steel blade with graduated markings similar to a 12-inch rule, a cast steel center head, a cast steel protractor head, and a cast steel stock head. Each of the heads is made to slide along the blade and clamp at any desired position. The center head is used to find the center of shafting or other cylindrical work. The protractor head can be

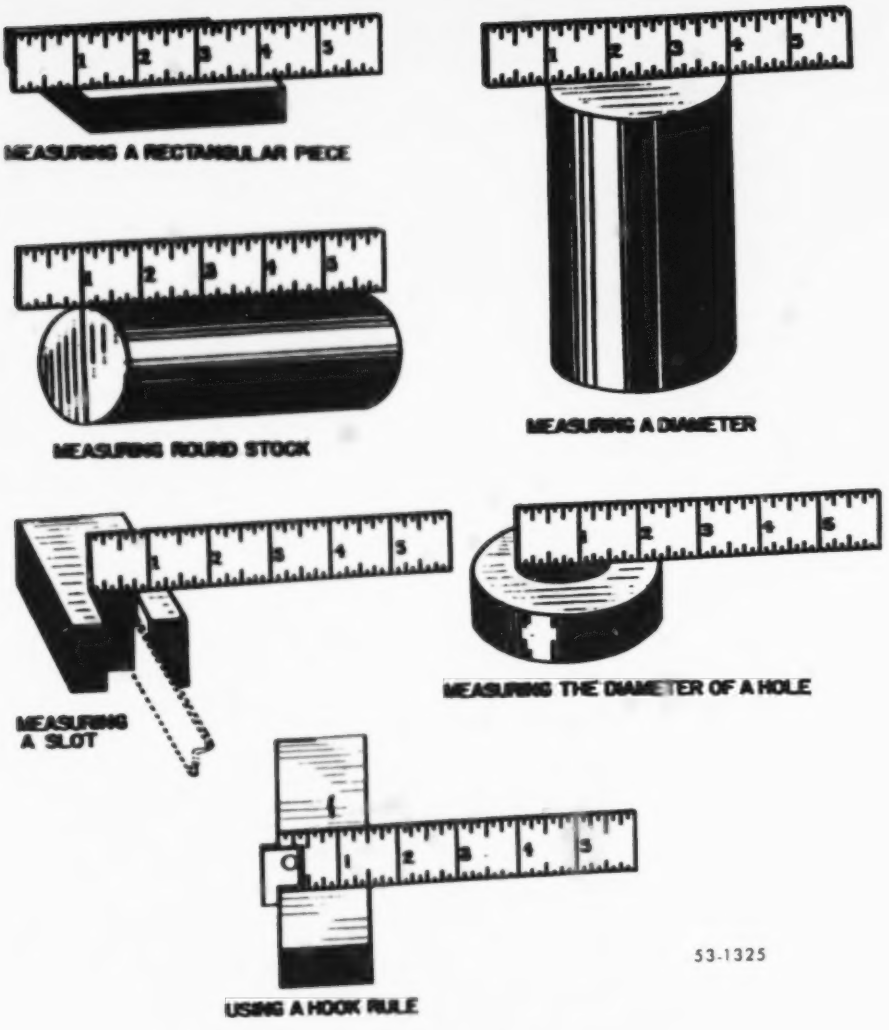


Figure 3-12. Uses for steel rule.

set at any angle to draw lines at angles from 0° to 180°. The stock head, sometimes called *square head,* has a spirit level and a scriber. It can be used to check the squareness of a shear cut, and the levelness of the cut at the same time. It can also be used as a simple level. Figure 3-17 indicates the various uses of the combination set.

Layout Punches. Of the variety of punches you may find in your tool kit, the prick punch and the center punch do double duty; they are also layout tools. The major difference between a prick punch and center punch is the angular degree of sharpness in their points (see fig. 3-18). Use the prick punch only for making fine punch marks along scribed lines to mark their position in case the lines are rubbed off or for locating centers of holes and centers for dividers legs during layout of circles and arcs. To increase the depth of hole centers preparatory to drilling, use the heavier-pointed center punch. You will have to grind the points of these punches frequently to keep thm sharp. Check the driving end of the punch at the same time to see that it is flat and perpendicular to the centerline of the punch; remove any dangerous burrs that form around the edges.

The included angle of the point of the center punch should be 120° to allow the 118° included angle of a standard ground drill to seat well into the bottom of the conical depression. If, as sometimes happens, the first location is slightly off center, you can correct it by tilting the punch and driving the point in the direction desired. When the error has been corrected, bring the punch to a vertical position and give it a sharp rap to insure a perfect new location for the drill point.

French Curve. Curved rulers, called irregular curves or sometimes French curves, as shown in figure 3-19, are used as mechanical guides for drawing curved lines other than circle arcs. The curves are made in patterns

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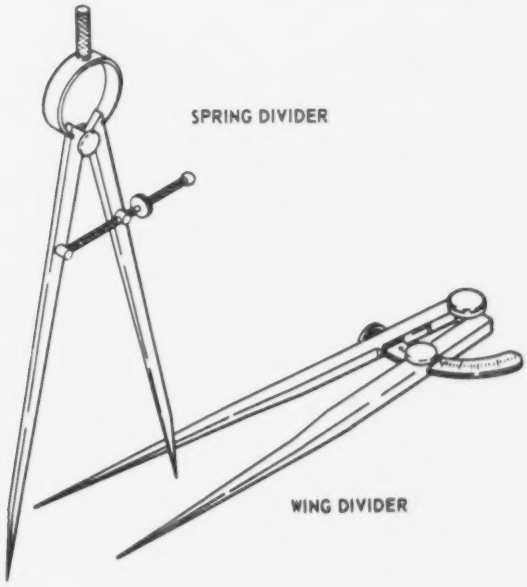
Figure 3-13. Scriber.

which feature parts of ellipses and spirals or other mathematical curves in various combinations. These curves are usually manufactured from transparent plastic. To use this tool, first mark a sufficient layout of plotted fixed points. When these points have been determined and marked, align the edge of the curve to these points by selecting portions of the curve which fit these points. Using a suitable marking pencil, produce a curved line by following the curved edges contacting the plotted fixed points. The complete layout will be determined by successive positioning of the curve until the line drawn covers all the points. In shifting the curve, take care to preserve smoothness and continuity of the drawn line. You can do this by positioning the curve so that it coincides for a short distance with part of the line already drawn. Always keep the curve flat to avoid warpage.

T-Squares. T-squares are made with a fixed head or an adjustable head. The T-square most often used has a hardwood blade with transparent plastic edges, with the blade attached rigidly to a hardwood head as shown in figure 3-20. This arrangement places the upper edge of the blade and the inner edge of the head at right angles; these are the working edges of the T-square. Use only the blade to draw horizontal lines.

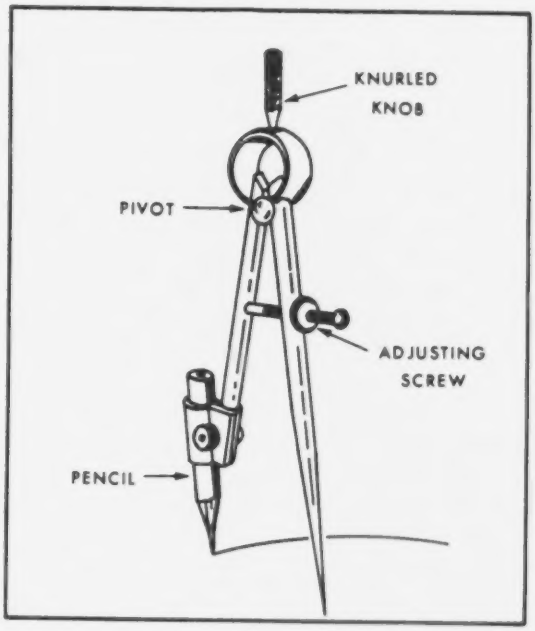


53-1317

Figure 3-14. Dividers.

Vertical or sloping lines are made with the aid of triangles. Always hold the T-square flat on the work area. Take care to avoid marring the blade edges. Place the head of the T-square at the left edge of the workboard (assuming you are right-handed) and hold it firmly while drawing.

Triangles. Triangles are usually made of transparent celluloid or plastic material. Two triangles are usually desirable, a 30-60° triangle and a 45° triangle as shown in figure 3-20. Standard sizes are 10 inches for the longest leg of 30-60° triangle and 8 inches for legs of 45° triangle. Vertical and sloping lines are drawn with the use of triangles. The base of the triangle should rest flat and on the edge of the blade of the T-square. As with the T-square, take care to avoid marring the edges.



53-1324

Figure 3-15. Pencil compass.

Exercises (236):

1. What two functions can be performed with a steel rule?

2. If you had to measure a distance over 12 inches long, what measuring tool would you select?

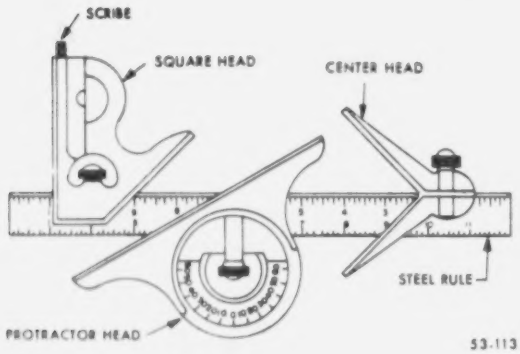


Figure 3-16. Combination set.

3. When would you use a scriber?

4. What types of measuring functions can be accomplished with dividers?

5. When is it necessary to use the projector head of the combination set?

6. Why is a center punch used instead of a prick punch to locate the centers of holes to be drilled?

237. Explain the safety feature of a micrometer ratchet and properly read given scale settings for outside and depth micrometers.

Micrometers. The type of measurement you wish to take determines which of the four types of micrometers (shown in fig. 3-21) you use. Use an outside micrometer to measure the outside diameter of shafts and the thickness of materials, and to set inside

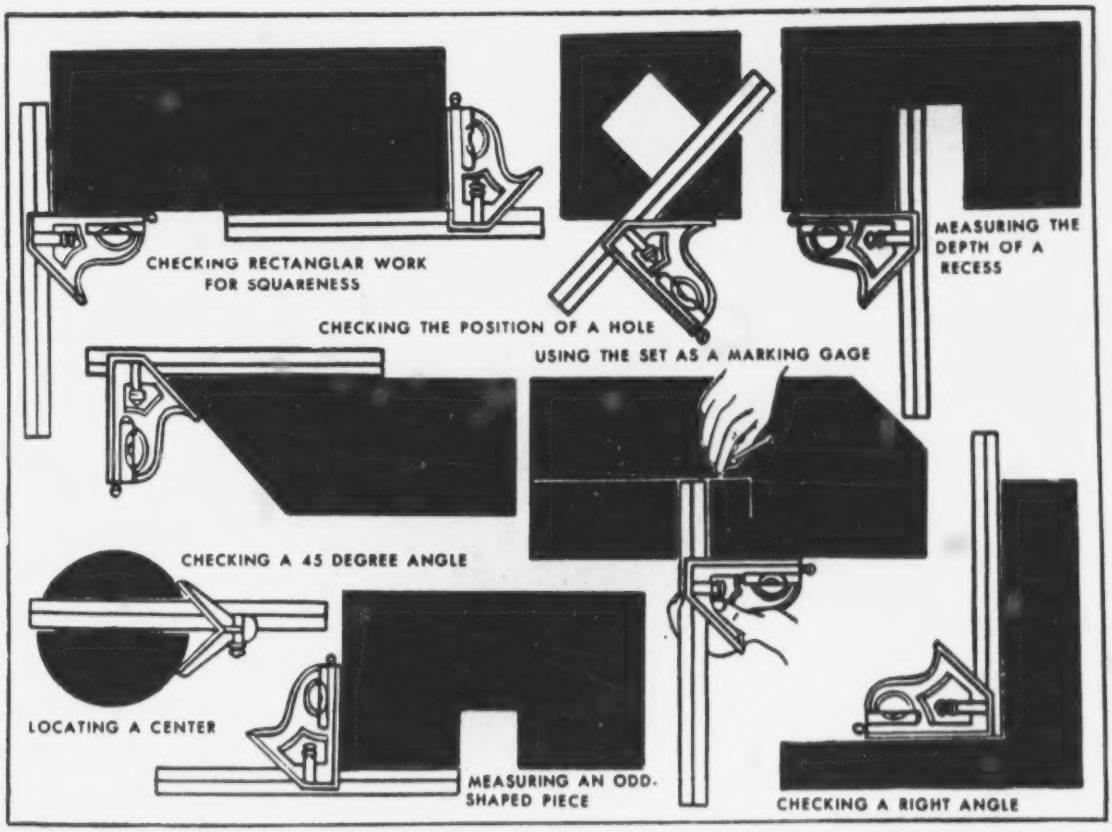

CHECKING RECTANGLAR WORK FOR SQUARENESS
CHECKING THE POSITION OF A HOLE
MEASURING THE DEPTH OF A RECESS
USING THE SET AS A MARKING GAGE
CHECKING A 45 DEGREE ANGLE
LOCATING A CENTER
MEASURING AN ODD-SHAPED PIECE
CHECKING A RIGHT ANGLE
53-1326

Figure 3-17. Uses of a combination set.

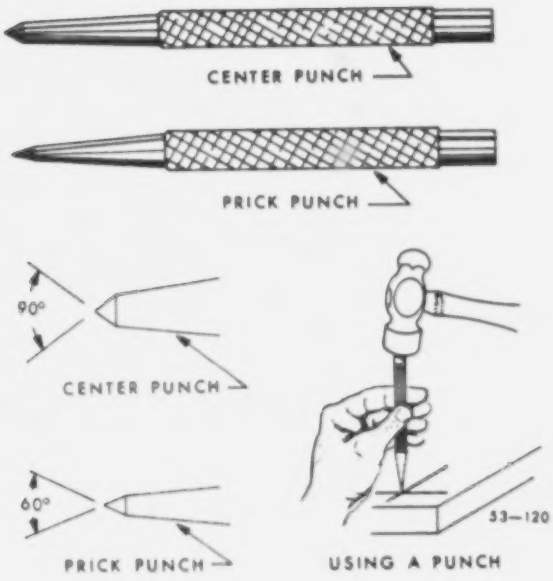


Figure 3-18. Center punch and prick punch.

calipers to a given dimension. Use an inside micrometer to measure the inside diameter of cylinders, the width of recesses, and other similar areas. Use a thread micrometer to measure the pitch diameter of screws and bolts. Use a depth micrometer to measure the depth of a recess or hole.

Figure 3-22 identifies the parts of an outside micrometer. An ordinary micrometer can measure to within 0.001 inch. When it is equipped with a vernier scale, it can measure to within 0.0001 inch. Always hold the spindle of an outside micrometer perpendicular to the work you are measuring and apply only very slight tension. Applying too much pressure can spring a micrometer as much as 0.003 inch. On many micrometers, a ratchet on the end of the spindle slips when the tension becomes great enough.

Using a Micrometer. The micrometer must be handled carefully. If it is dropped, its accuracy may be permanently affected. The anvil and spindle surfaces may become worn through a process of continually sliding work in and out of the micrometer. If the spindle is tightened too much, the frame may be sprung permanently and inaccurate readings will result. How you measure work with the micrometer varies slightly according to what kind of object you are measuring.

The proper way to hold a micrometer in checking a small part is shown in figure 3-23,A. Hold the part in one hand. Hold the micrometer in the other hand so that the thimble rests between the thumb and the forefinger. The third finger is then in a position to hold the frame against the palm of the hand. The frame is supported in this manner and makes it easy to guide the work over the anvil. The thumb and forefinger are in position to turn the thimble either directly or through the ratchet and bring the spindle over against the work.

On larger work, it is necessary to have the work stationary and positioned to permit easy use of the micrometer. The proper method of holding a micrometer when checking a part too large to be held in one hand is shown in figure 3-23,B. Hold the frame by one hand to position and to locate the frame square to the measured surface. The other hand operates the thimble either directly or through the ratchet. A large flat part should be checked in several places to determine the amount of variation.

To gage a shaft as shown in figure 3-23,C, hold the frame by one hand while you operate the thimble with the other. In gaging a cylindrical part with a micrometer it is necessary to feel the setting to be sure that the spindle is on the diameter, and also to check the diameter in several places to determine the amount of out-of-roundness.

Reading Micrometers. Reading a micrometer is simpler than it appears. A micrometer can measure because of the spindle, which is driven by the spindle screw. Since this screw has a pitch of 40 threads per inch, turning the thimble 40 complete revolutions moves the spindle exactly 1 inch. A clockwise turn moves the spindle toward the anvil; a counterclockwise turn moves the spindle away from the anvil. You can easily understand, then, that a single revolution from one screw thread to the next moves the spindle 1/40, or twenty-five thousandths (0.025), of an inch (1.000 inch divided by 40 equals 0.025 inch). Along the barrel in figure 3-22, you can see a figure 2 over the eighth graduation to indicate 2/10 inch (8 times 0.025 = 0.200). In figure 3-22 the thimble has not traveled a full graduation past the 2 point; therefore, the measurement reads 0.200 inch (0.200 inch is signified by the number 2) plus some yet unknown quantity because the spindle has gone past the number 2 graduation. Now look at the graduation on the thimble. Since the circumference of the thimble is divided into 25 equal spaces, each graduation represents 1/1000 inch (0.001 inch). With a reading of 0.200 inch on the barrel and a reading of 23 graduations past the zero point on the

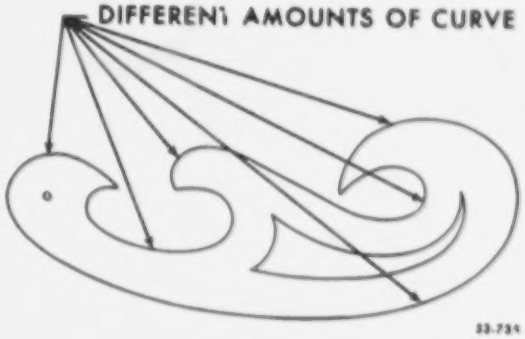


Figure 3-19. French curve.

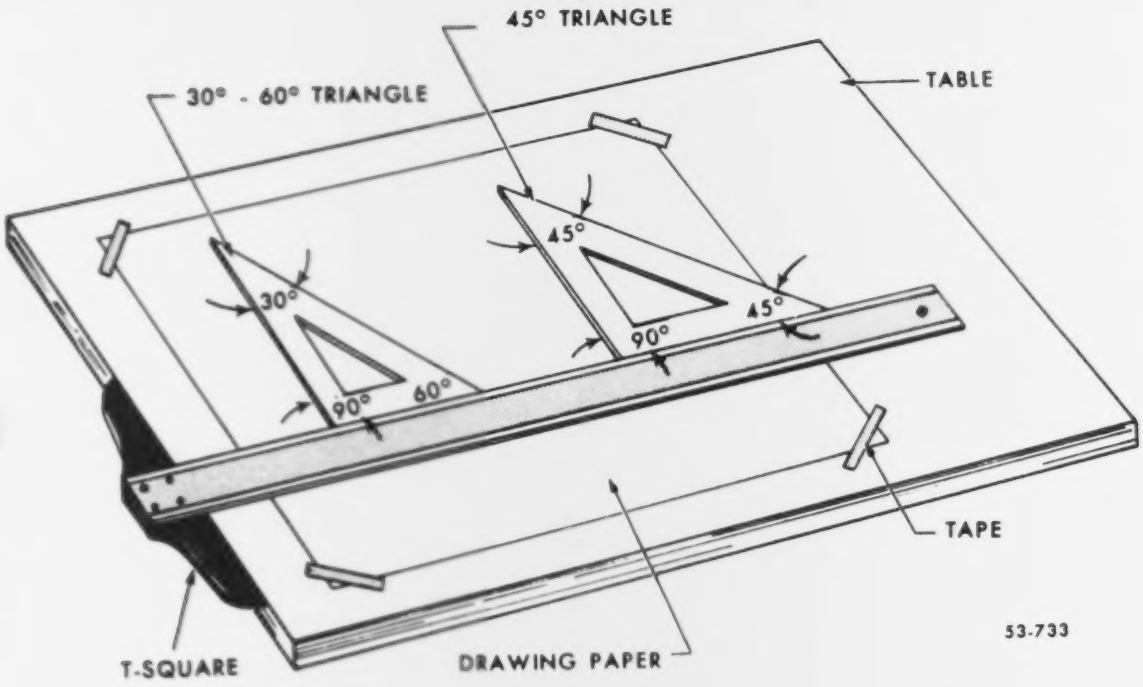


Figure 3-20. Drawing board setup.

thimble, the final measurement is two hundred twenty-three thousandths of an inch (0.223 inch). Figure 3-24 shows some additional micrometer settings and readings. Study them until you are certain that you understand how the readings are obtained. (Question: What is the reading on the bottom micrometer?)

Some micrometers have a vernier scale. Note the illustration in figure 3-25. The graduations on the barrel that parallel the length of the barrel (and parallel the reference line) make up the vernier scale. Note that the ten divisions on the vernier scale equal nine divisions on the thimble scale, and keep in mind that each division on the thimble scale represents 0.001 inch. In figure 3-25, the zero at either end of the vernier scale aligns with a graduation on the thimble scale. This is true when any graduation on the thimble scale aligns exactly with the reference line of the tenths scale on the barrel. Now, if you turn the thimble counterclockwise s-l-o-w-l-y, you can see the numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, and 0 on the vernier scale align in sequence with a different graduation on the thousandths scale on the barrel. This means that the spindle moves (endwise travel) 1/10 of 0.001 inch, or 0.0001 inch, each time the next graduation on the vernier scale aligns with a graduation on the thimble scale. Moving the spindle 0.001 inch causes 20 on the thimble scale to align with the reference line of the tenths scale on the barrel and causes both 0 graduations on the vernier scale to align with the next graduations on the thimble scale. In figure 3-25,B, the 7 on the vernier scale aligns with a graduation on the thimble scale; therefore, the reading is:

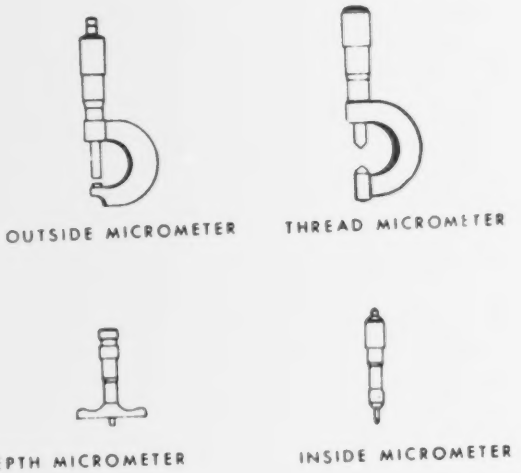


Figure 3-21. Types of micrometers.

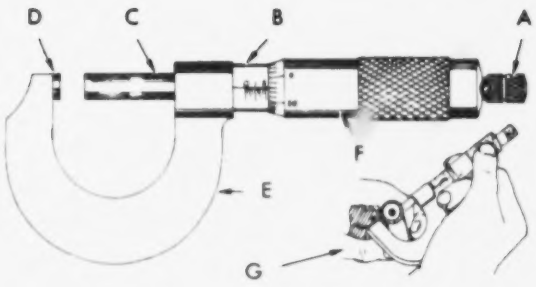


Figure 3-22. Outside micrometer.

0.4690 inch
+0.0007 inch
0.4697 inch

Types of Micrometers. The measuring range of an outside micrometer is 1 inch. A 1-inch micrometer can measure from 0 to 1 inch; a 2-inch micrometer from 1 to 2 inches, etc. Therefore, six different sizes of outside micrometers are required to take measurements from 0 to 6 inches. However, only one inside micrometer and only one depth micrometer are required for measurements through a 6-inch range because they make use of extension rods. Note the inside micrometer in figure 3-26. The body of this inside micrometer is 1½ inches long and its measuring range is 0.500 inch. With this inside micrometer, you cannot measure dimensions smaller than 1½ inches. To measure dimensions greater than 2.0 inches, you use extension rods of various lengths. A measurement taken with an inside micrometer must include the length of the body and the length of the extension rod. For example, assume that you are using a 3-inch extension rod and the reading is 0.358 inch. What is the actual dimension? It is determined as follows:

3.000 inches—length of extension rod
1.500 inches—length of body
0.358 inch—reading
4.858 inches—actual dimension

The range of measurement of most depth micrometers is 1 inch. Note the depth micrometer in figure 3-21. Extension rods permit the measurement of various distances: 0 to 1 inch, 1 to 2 inches, 2 to 3 inches, etc. The extension rod extends through the center of the thimble and barrel and protrudes through the hole in the base of the micrometer. When the thimble is turned to the 0.000 position, the tip of a 0- to 1-inch extension rod is flush (even) with the flat reference surface of the base. When a 0.000 reading is indicated, the top of a 1- to 2-inch extension rod extends exactly 1 inch from the base. The measurement obtained with a depth micrometer must include the lower value of the extension rod being used. For example, if you are using a 0- to 1-inch rod and the reading is 0.567, the actual measurement is 0.567 inch, but if you are using a 1- to 2-inch rod, the actual measurement is 1.567 inch.

The graduations on a depth micrometer are the reverse of those on an outside micrometer. The 0.000 reading is obtained on an outside micrometer with all the graduations on the barrel covered by the thimble; the 0.000 reading is obtained on a depth micrometer with all the graduations exposed. This makes it a little more difficult to read a depth micrometer. For example, suppose that the reading on both micrometers is 0.775 inch. On the depth micrometer, all the graduations from 0.000 through 0.750 are covered and

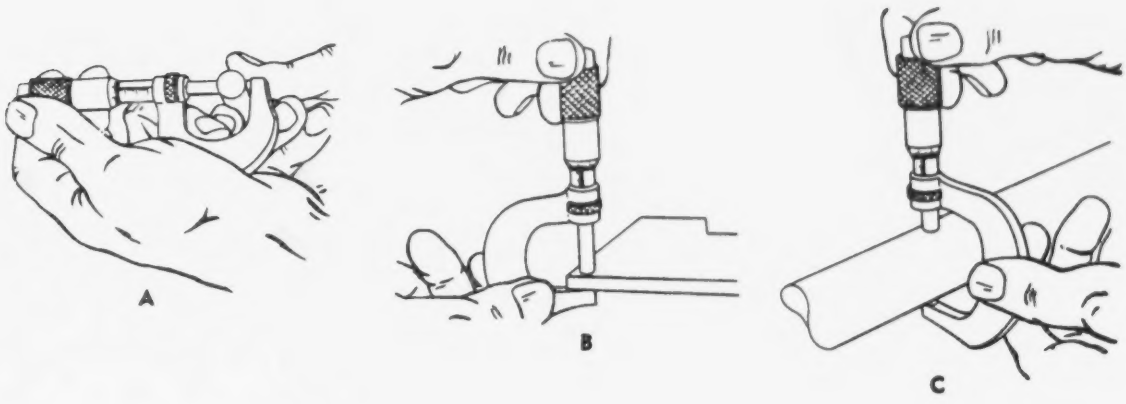


Figure 3-23. Measuring using a micrometer.

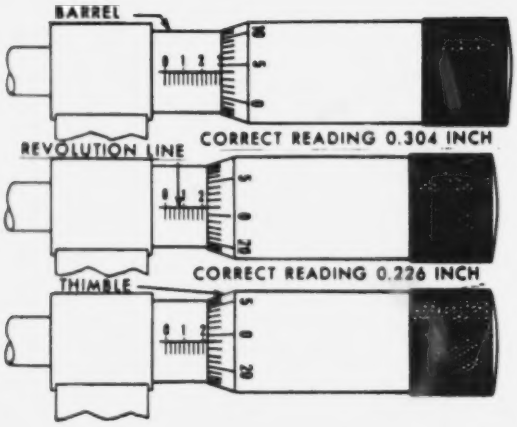


Figure 3-24. Micrometer readings.

on an outside micrometer they are all exposed. The 0.800 graduation on the depth micrometer is exposed and on the outside micrometer it is covered. If you are not careful, you might read 0.825 on the depth micrometer instead of 0.775.

Micrometer Care. Always handle a micrometer with care to preserve its accuracy. Never swing an outside micrometer by the thimble. Apply a very light film of oil from time to time to prevent it from rusting. Do not store it with the spindle and the anvil closed tightly, as this can impair its accuracy. Keep the micrometer clean and make sure that the surfaces being measured are free of dirt, corrosion, and burrs.

Exercises (237):

1. Refer to figure 3-24 and give the micrometer reading for the example that does not show the reading (the bottom micrometer).

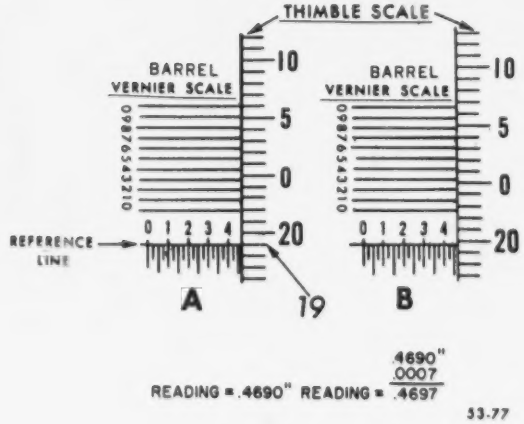


Figure 3-25. Vernier scale.

2. One complete turn of the thimble moves the spindle of the micrometer _____.

3. What is the purpose of the ratchet on a micrometer?

4. On a depth micrometer with the graduations from 0.000 to 0.675 on the barrel covered, and the zero (0) on the thimble aligned with the revolution line, the reading is _____.

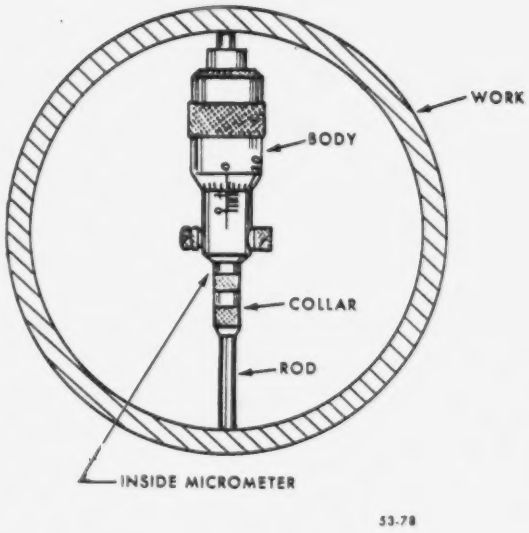


Figure 3-26. Inside micrometer.

238. Determine the type of measuring gage to use in a given situation.

Gages are measuring instruments that are fixed. They have a series of openings of definite width, or leaves of definite thickness. They are made of hard steel so as not to lose their accuracy with use. Gages most generally used by the airframe repairman are listed in the following paragraphs.

Thickness Gage. The thickness gage has a series of thin leaves, each ground to a definite thickness which is marked on the leaf. The leaves are usually in sets, with one end fastened in a case. Figure 3-27 shows a typical thickness gage.

Use the thickness gage to measure clearances. Clean the leaf before attempting to insert it into the opening. When a leaf of the proper thickness is not available, use two leaves together.

Twist-drill Gage. The twist-drill gage is a smooth-finish steel plate, round or rectangular, containing a series of round holes that correspond in size to a series of drills. Use the twist-drill gage when you need to drill a hole for wire, a rivet, or similar part. To select the proper size drill, fit the rivet (or wire, etc.) in the holes of the twist-drill gage. You can also use the gage to determine sizes of drills corresponding to size markings on the gage (fig. 3-28).

Sheet Metal and Wire Gage. The sheet metal and wire gage is very similar to the twist-drill gage, except for gage slots on the outer edge. There are several standard gages, such as American Standard, English Standard, and U.S. Standard. The American Standard, shown in figure 3-29, is the most commonly used gage for aircraft sheet metal and wire. Determine the thickness of sheet metal or wire by placing the sheet metal or wire into the slots of the gage until you find the correct fit.

Thread Gage. The thread gage is similar to the thickness gage, except the leaves are all of the same thickness and the edges of the leaves have teeth. The number of teeth per inch is marked on each leaf, and the number varies from leaf to leaf. Use the thread gage to determine the threads per inch on bolts and screws by selecting the leaf of the gage that corresponds to the threads of a bolt or screw, as shown in figure 3-30.

Radius Gage. The radius gage is similar to the thickness gage, but all leaves have the same thickness and the sides of each leaf are curved at a definite radius. The radius is marked on each leaf. Use the radius gage as shown in figure 3-31 to determine the radius of curved surfaces by selecting the leaf of the gage that corresponds to the surface being gaged. Notice that each leaf is shaped so you can measure either an inside or an outside arc.

Drill Grinding Gage. The drill grinding gage, shown in figure 3-32, is shaped like the letter T, with the ends of the crossbar of the T cut off at an angle of 59°. This is the correct angle for the cutting lips of a drill. The edge of the gage is marked in ⅛-inch divisions to measure the length of the lips as well as the angle of the drill.

Exercises (238):

1. What would you use to measure clearances?

2. If you didn't have a micrometer, what other type of measuring device could you use to measure the thickness of a piece of metal?

3. In checking a twist drill, what do you use to measure its diameter and the angle of its cutting lips?

4. What gage do you use to determine whether a bolt has the proper threads?

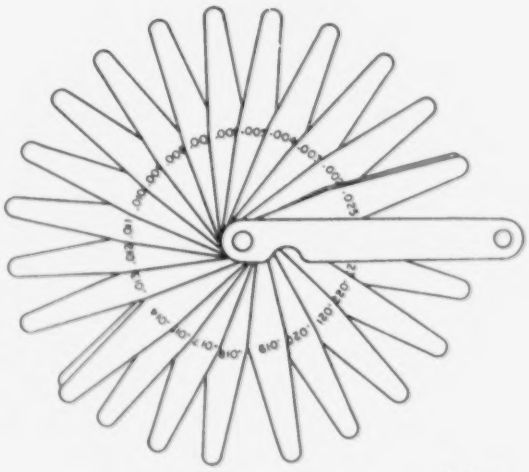
5. Which particular type gage is very helpful for checking the accuracy of small bends and rounded edges in formed metal?

3-4. Hand Cutting Tools

Very often, you will find it impractical to use power-driven metal tools because of the type of location of the work. Therefore, you must rely on hand-held cutting tools and the skill you have developed in using them. There are several methods of cutting sheet metal with hand-held tools, and naturally several kinds of tools. Among the most frequently used are straight snips, aviation snips, files, chisels, and hacksaws.

239. Given a work situation, select the proper metal-cutting snips.

Straight Snips. Metal-cutting straight snips, commonly known as tinner's snips, are designed for cutting thin sheets of metal. Metal-cutting straight



53-1328

Figure 3-27. Thickness gage.

snips (fig. 3-33) resemble scissors with long handles and short blades. They consist of two cutting edges held together with a pivot screw or bolt. These snips vary from 6 to 16 inches in length and are made with either straight or curved blades.

Procedures. Never use these snips on tempered steel; it is too hard for them and will ruin the cutting edges. The straight snips are designed for right-handed operators, so the cutting line can always be in full view for accurate cutting. Hold the snips in the right hand so that the flat sides of the blade are at a right angle to the work surface. If you don't hold the snips at a right angle, the edges of the cut will be slightly bent and burred.

To use the straight snips, place the metal being cut on a table or bench, with a marked guideline along the edge of the table (fig. 3-34,1). Hold the sheet down with one hand. While cutting, keep the metal well back into the jaws of the snips to make the cutting easier. Use the edge of the table to steady the snips and keep them at the correct angle for the cutting. This allows the scrap metal portion of the work to bend downward so it does not interfere with cutting. If making a curved cut (fig. 3-34, 2), make the cut in a counterclockwise direction when possible, to allow seeing the guideline. Once started, cut without stopping, because starting and stopping causes rough edges.

At times, to cut notches or make other small cuts, it is practical to use only the tips of the straight snips. When nearing the end of the line-of-cut in a long cut, use the tips of the snips to finish the cut, so the snips do not go beyond the stopping mark.

Care. Place these snips in a special compartment of the toolbox when not in use. Because the snips can be bent or broken, do not throw them into a toolbox where heavy objects can be piled or dropped on them. Wash grease or dirt from the snips with a solvent and dry them with a soft cloth. Apply a light coat of oil before prolonged storage to prevent rust. Lubricate the pivot screw or bolt with light oil frequently and keep it tight enough to prevent sideplay, but not tight enough to cause binding. Do not spring the jaws of these snips by trying to cut wire, cable, or similar materials with them, and do not use them on metal that is heavier than they are designed to cut.

Touch up the cutting edge frequently with an oilstone to avoid the need for filing or grinding. Dull snips usually can be sharpened with a file, without grinding. To sharpen them with a file, clamp the snips in the soft jaws of a vise and use a flat file as shown in figure 3-35. Do not file the flat face of the blade. Use the file on the beveled cutting edge only. Stroke the file across the beveled edge, away from yourself. Use the full length of the file in a diagonal stroke.

If the blades of the snips get badly nicked or the bevel gets distorted, the cutting-edge will have to be ground. First determine the correct bevel angle, usually about 85°, by examining an undamaged portion of the bevel. Set the grinder tool rest to give the correct bevel, and put the cutting edge side down against the tool rest, steadying it with the forefinger

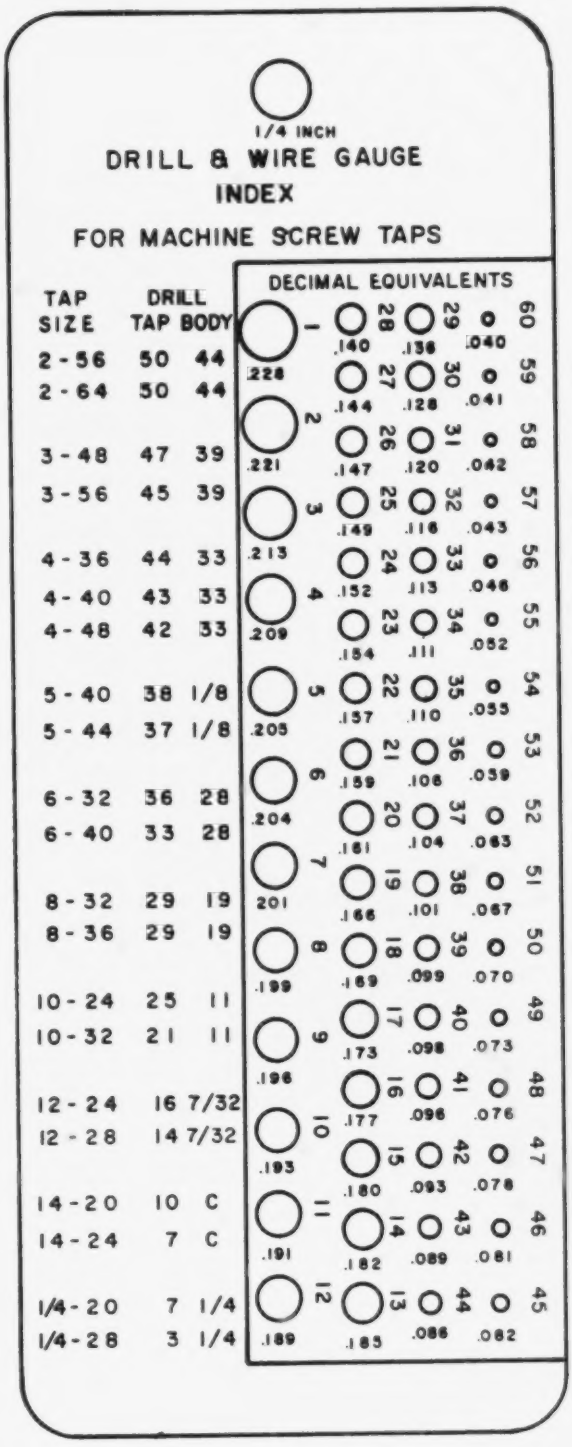


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Figure 3-28. Twist-drill gage.

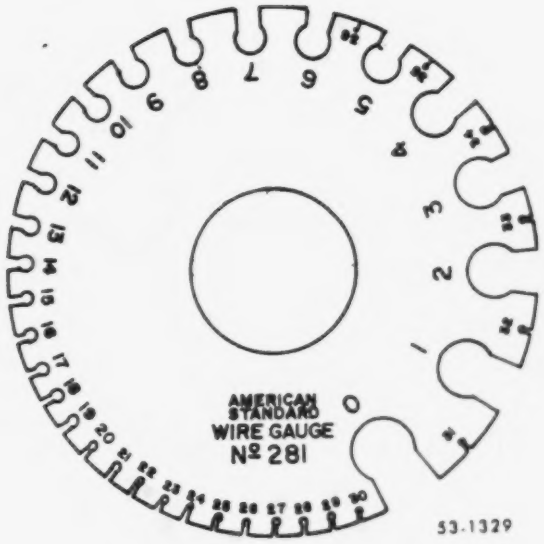


Figure 3-29. Sheet metal and wire gage.

against the tool rest. Move the bevel into contact with the turning grindstone and move the blade continually from side to side in a uniform motion to insure an even cutting edge. Dip the blade in water frequently when grinding to preserve its temper.

Aviation Snips. Aviation snips, as shown in figure 3-33, are designed especially for cutting heat-treated aluminum alloy and stainless steel. They are also adaptable for enlarging small holes. The blades have small teeth on the cutting edges and are shaped for cutting very small circles and irregular outlines. The handles are of the compound-leverage type, making it possible to cut material as thick as 0.051 inch. Aviation snips are available in two styles, those which cut from right to left and those which cut from left to right.

Never use snips as pliers or wire cutters, nor on heavier material than that for which they are intended. Such improper usage may spring the blades and make the snips useless. When cutting, place the upper blade of the snips on the line to be followed and keep the blade perpendicular to the surface of the metal. The waste metal (or the smaller piece) should curl up along the upper edge of the lower blade.

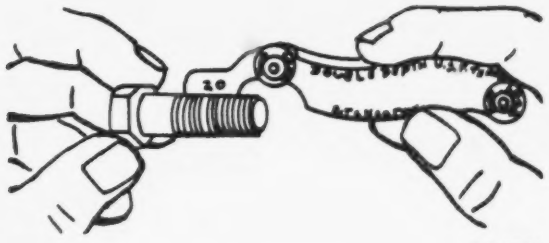


Figure 3-30. Thread gage.

Exercises (239):

1. If you had to enlarge a small hole in a piece of metal, which type of snips would you select?

2. If you had to cut out a triangle 6 inches on each side from a piece of metal, which type of snips would give you the best results?

3. Why should the cutting direction be counterclockwise when using straight snips to cut out a circle?

4. If you are using the upper blade as a guide during a cutting operation, what kind of snips are you probably using?

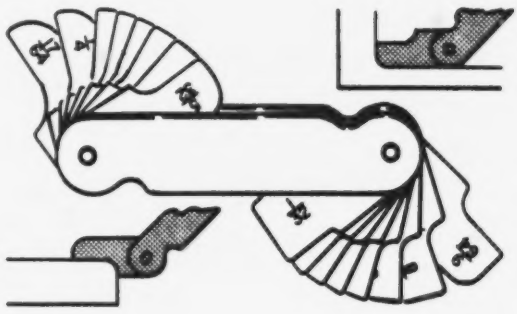


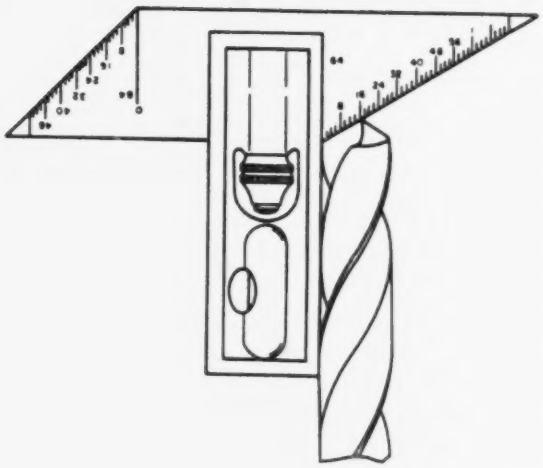
Figure 3-31. Radius gage.

5. If you are grinding a straight bevel to restore the cutting edge of snips, what kind of snips should they be?

240. Give the correct file and filing procedures for doing a specific job.

No shop or individual toolkit is complete without at least several files. Figure 3-36 illustrates the six shapes of files you most often use.

Files are very useful tools, but their life and usefulness depend a great deal upon the way they are used and maintained. To keep them working well, clean



53-1327

Figure 3-32. Drill grinding gage.

them frequently with a file card or brush and keep them separated from other tools to prevent damage to the other tools.

Files are usually made in two types of cuts, single-cut and double-cut, as shown in figure 3-36. The single-cut file has a single row of teeth extending across the face at an angle from 65° to 85° to the length of the file. The size of the cuts depends on the coarseness of the file. The double-cut file has two rows of teeth which cross each other. For general work, the angle of the first row is from 40° to 45°. The first row is generally referred to as "over-cut"; the second row is referred to as "up-cut," the up-cut being somewhat finer and not as deep as the over-cut.

Single-cut files are recommended for sharpening cutting tools, such as the blades of shears and snips. Apply light pressure to single-cut files to obtain a smooth finish. Use double-cut files when a rough finish is permissible and heavy pressure may be applied for fast cutting.

One of the factors in selecting a file is the composition of the metal to be filed. An example is stainless steel, which is hard and requires a file with a deep up-cut and fine over-cut.

The parts of a file, as illustrated in figure 3-36, are the tang, face, heel, and point. Generally, all files are manufactured in the same way. A file flank of carbon steel is heated, the teeth are cut into it, and it is quenched in water to harden it. This method has the disadvantage of making the file brittle.

Types of Files. Refer to figure 3-36 as we discuss the various types of files you most often use.

Half-round. Half-round files are not complete half-circles as the name implies, since the arcs are about one-third of a circle. They are available in all cuts except dead smooth. They are double-cut, tapered in width and thickness toward the point, and have one flat and one oval side. They are primarily used for filing concave surfaces.

Mill. Mill files are tapered slightly in thickness and in width for about one-third of their length. They are single-cut in either bastard, second-cut, or smooth. Mill files are available with square edges and with one or two round edges for filing gullets between saw teeth. They are used principally for sharpening mill or circular saws, edge tools, machine knives, and also for lathe work, draw filing, and for finishing compositions of brass and bronze.

Flat. Flat files are tapered slightly toward the point in both width and thickness. They are double-cut on both sides and single-cut on both edges. They are available in bastard, second-cut, and smooth-cut, and are used for all common filing operations.

Square. Square files are square in cross-section, tapered or blunt, and are double-cut on all four sides. They are made in bastard, second-cut, and smooth

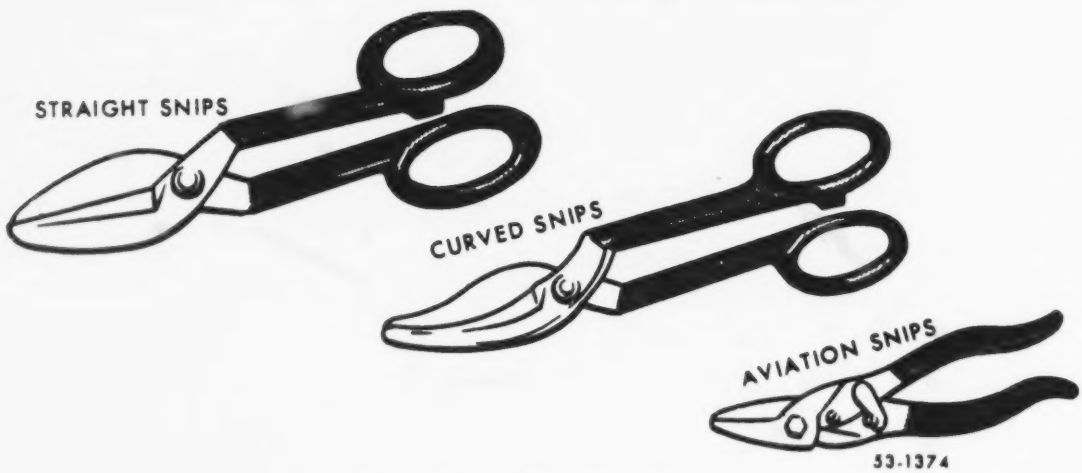


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Figure 3-33. Types of metal cutting snips.

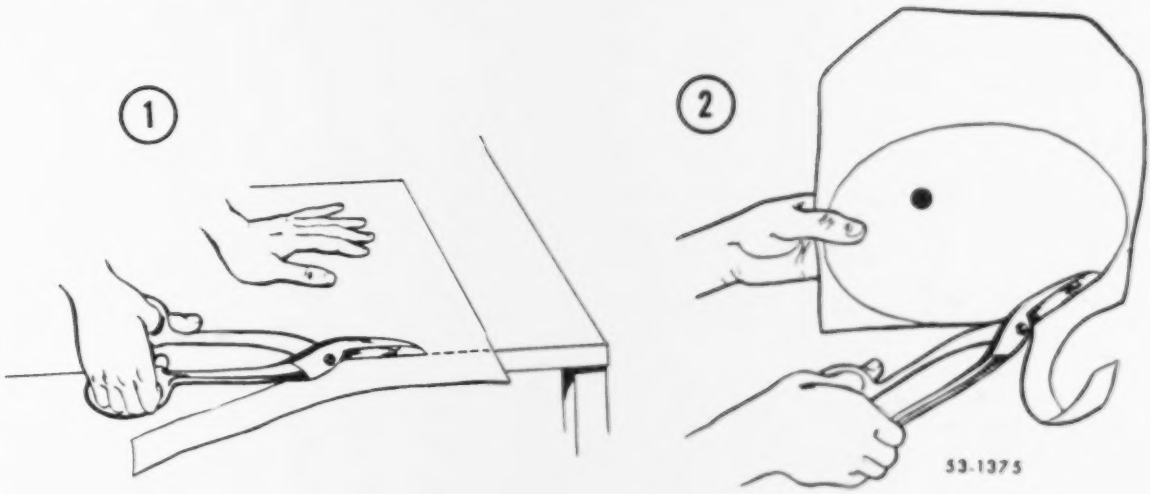

Figure 3-34. Using straight snips.

forms and are used for filing keyways, slots, corners, and general surface filing.

Triangle. Three-corner files are triangular in cross-section, tapered or blunt, with edges left sharp and cut. They are double-cut and are made in bastard, second-cut, and smooth forms. They are used by machinists for filing acute internal angles, clearing out square corners, and filing cutters and taps. Taper files are also triangular in shape, but are single-cut.

Round. Round files are circular in cross-section, tapered or blunt, and are single or double-cut. They are made in bastard, second-cut, and smooth forms. Round files are principally used to file or enlarge circular openings or to file concave surfaces.

Procedures. When using a file, hold the handle in your right hand with your fingers underneath and your thumb on top. With your left hand, grip the point of the file between the thumb and fingers. (This position is the preferred grip, but the job and location may force you to use a different grip.) If possible, the work should be at the height of your elbow. This position lets you file in long, smooth strokes of approximately 60 per minute.

Filing too fast will actually cause the points of the teeth to get hot enough to lose their hardness. Do not put pressure on the file as you draw it back over the material, because the teeth slant forward and the pressure on the back stroke may break them off. An exception to this rule is in the filing of very soft metals, such as lead, solder, or aluminum. When working with these metals, apply a slight pressure on the back stroke. Soft metals will not break the teeth, and the slight pressure aids in cleaning the file.

Crossfiling. In moving the file endwise across the work, commonly known as crossfiling, grasp the handle in such a manner that its end fits into and against the fleshy part of your palm, with your thumb lying lengthwise along the top of the handle as in figure 3-37. Grasp the end of the file between your thumb and first two fingers. To prevent undue wear, relieve the pressure during the return stroke. Hold narrow work surfaces near the vise jaws to prevent vibration. If a surface is straight, place it parallel to the top of the vise.

Drawfiling. A file is sometimes used by grasping it at each end, crosswise to the work, then moving it lengthwise with the work (fig. 3-38). When done properly, this method gives a finer finish than crossfiling with the same file. In drawfiling, the teeth of the file should produce a shearing effect. To accomplish this, you must vary the angle at which the file is held with respect to its line of movement, depending on the angle at which the teeth are cut. Also relieve the pressure during the back stroke as in crossfiling.

Rounding corners. The method used in filing a rounded surface depends upon the width and radius of

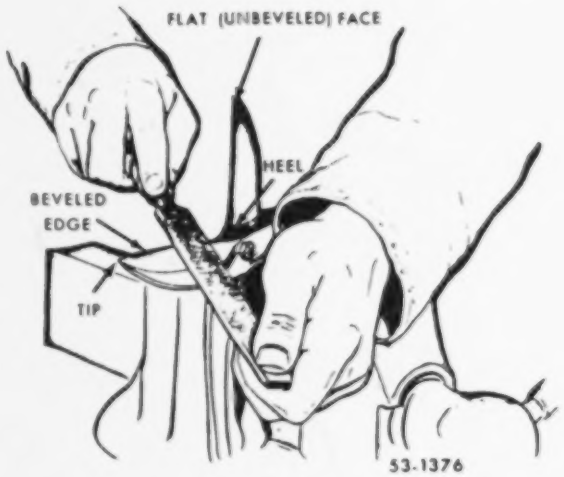

Figure 3-35. Sharpen straight snips.

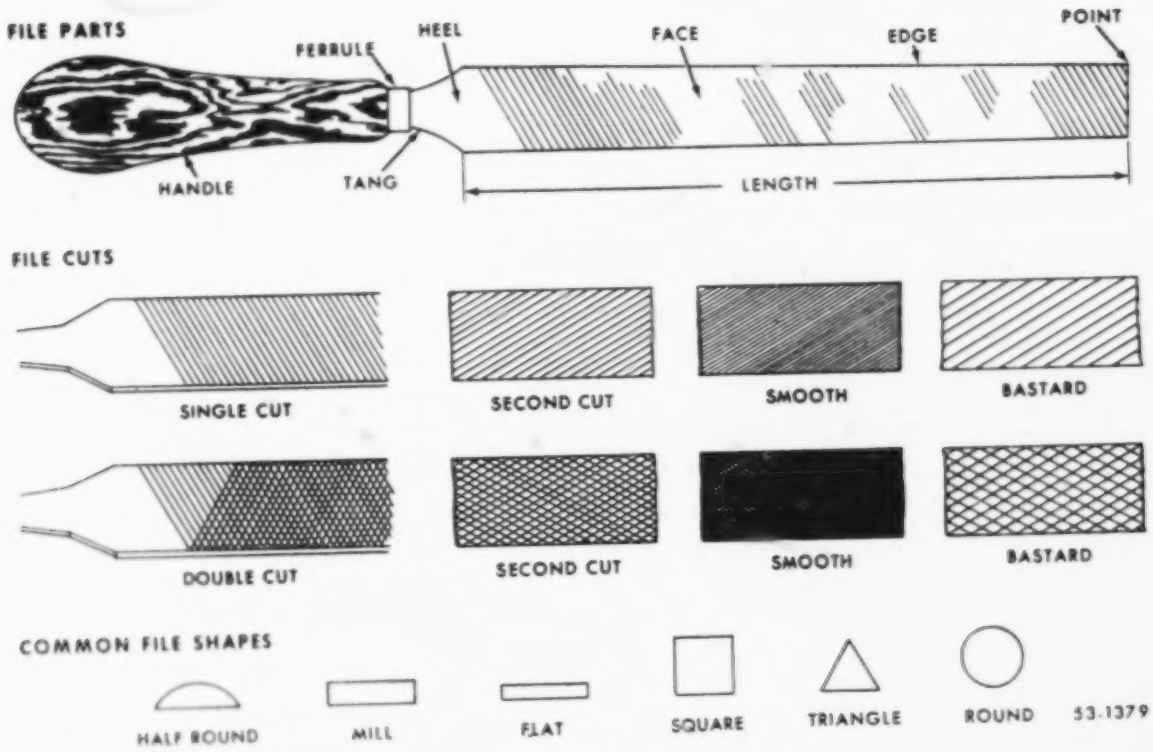

Figure 3-36. Files.

the rounded surface. If the surface is narrow in width or only a portion of a surface is to be rounded, as shown in figure 3-39, follow the method shown. This method allows use of the full length of the file.

Cleaning Files. Particles of metal collect between the teeth of a file and may make deep scratches as the file passes over the work. When these particles of metal are lodged too firmly between the teeth and cannot be removed by tapping the edge of the file, remove them by using a file card or wire brush (fig. 3-40). Draw the brush across the file so that the bristles pass down the gullet between the teeth. You can also use a little oil or chalk on a file to help prevent chips from sticking to the teeth.

Precautions. Never use a file without a handle. A file with a handle is much easier to use and less likely to injure your hands. Never use a file as a pry or a hammer. The metal is too brittle and will probably break.

Exercises (240):

1. Select the correct type file in column B to use. Record your selection in the blank in front of each file operation in column A.

Column A	*Column B*
_____ 1. Sharpening edge tools.	a. Half-round.
_____ 2. Enlarge circular openings.	b. Mill.
_____ 3. Form keyways.	c. Flat.
_____ 4. For common filing operation.	d. Square.
_____ 5. Filing concave surfaces.	e. Triangle.
_____ 6. Filing cutters and taps.	f. Round.

2. What type of file cut do you use to sharpen shears or snip blades?

3. When should you use a slight pressure on the back stroke while filing?

4. When would you drawfile a piece of metal?

5. What substances can you place on a file to prevent clogging of the file gullets?

6. What is the main thing to remember when using a file?

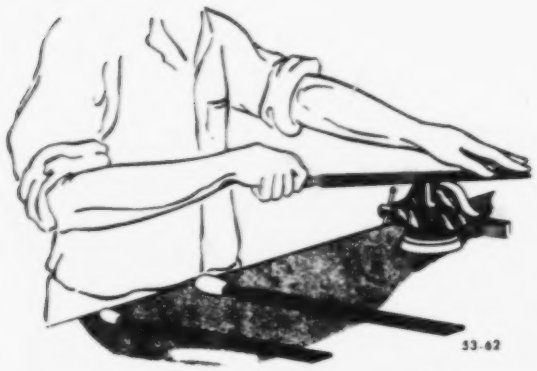

Figure 3-37. Crossfiling procedures.

7. Why is pressure on the back stroke usually *not* permitted when filing?

8. How should material for filing be positioned in a vise?

241. Select the common chisel and give some features of the proper use and care.

Types of Chisels. A chisel is made of a hard, tough metal, usually tool steel. A cutting edge is ground on it and it is usually shaped like one of the four common types illustrated in figure 3-41.

Flat chisel. The flat (cold) chisel is the most common and has a cutting edge ground at an angle from 60° to 70°. The flat chisel is used for cutting sheet metal, chipping, cutting heads off screws, and cutting flat stock.

Cape chisel. The uses of the cape chisel include cutting grooves, slots, and keyways, and chipping flat surfaces too wide for a flat chisel.

Half roundnose chisel. The purpose of the half roundnose chisel is to cut round (concave) grooves.

Diamond point. Chisels shaped to a diamond point are used for cutting V-shaped grooves.

Use of Chisels. To use a chisel, you must first select the right type. Next, hold the chisel firmly and strike the head of the chisel with short quick blows. Be sure to strike the head with the full face of the hammer, as shown in figure 3-42. To do a good job, watch the cutting edge of the chisel, not the head.

Care of Chisels. The care of chisels is very important and includes sharpening and dressing the chisel head.

Sharpening. Chisels, like all cutting tools, must be sharp to give satisfactory service. The cutting angle should be 60° to 70° and the edge slightly rounded. The sharpening is usually done on an ordinary coarse grinding wheel. If you press the chisel too hard against the wheel, you will generate enough heat to remove some of the hardness from the steel. If you grind the cutting angle too small, the chisel is not safe to use. If the angle is too great, the tool cannot cut properly. Figure 3-43 shows the results of correct and incorrect sharpening.

Mushroom head. The blows of the hammer eventually cause the head of the chisel to spread out until it resembles a mushroom. When this happens, grind the head back to its original shape. It is danagerous to use

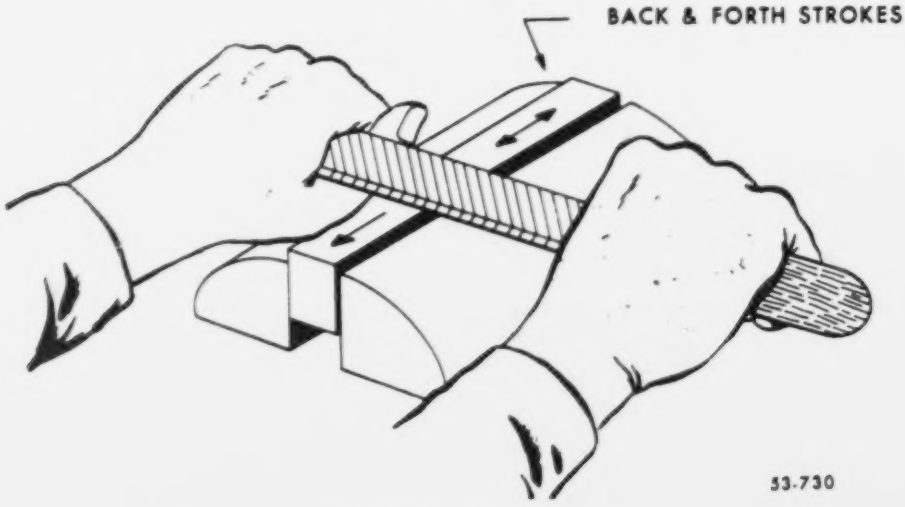

Figure 3-38. Drawfiling procedures.

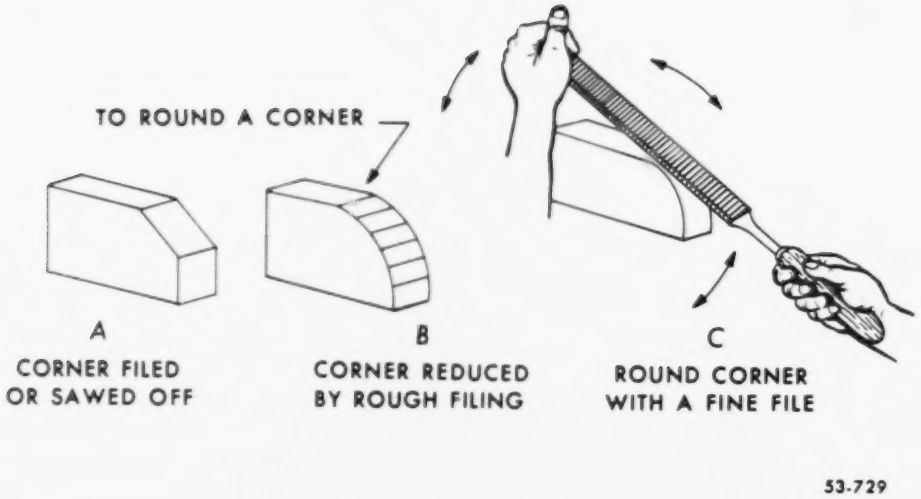

Figure 3-39. Rounding corners.

a chisel with a mushroomed head because pieces may fly off and cause injury. Figure 3-44 shows a dressed chisel head.

Exercises (241):

1. List the proper uses of the flat chisel.

2. When sharpening a chisel, you may soften it and cause it to lose hardness by _____.

3. State the proper use of the diamond point chisel.

4. Which of the following are common chisels?
   a. Square.
   b. Diamond.
   c. Standard.
   d. Cape.
   e. Roundnose.
   f. Flat.

242. Determine the correct hacksaw blade for stated situations.

Hand Hacksaw. Hacksaws are designed to cut metal in much the same fashion as a carpenter's saw cuts wood. However, the hand hacksaw becomes one of the most abused cutting tools because the materials to be cut so often vary in shape, thickness, and the angle or curve of the required cut. You must, therefore, develop a thorough understanding of the correct usage of this saw in order to cut metal efficiently with the least strain or damage to the tool. Always give due consideration to the following:

a. The type of saw frame.

b. The composition, heat treatment, dimensions, pitch, and set of the saw blade teeth.

c. The size, shape, and composition of the material to be cut.

d. The actual performance of the cutting operation.

Hand hacksaws, illustrated in figure 3-45, can be obtained in two styles, pistol grip and straight. The hand hacksaws consists of a frame, handle, and blade. Hacksaw blades come in lengths of 6 to 16 inches, although the 10-inch size is most commonly used.

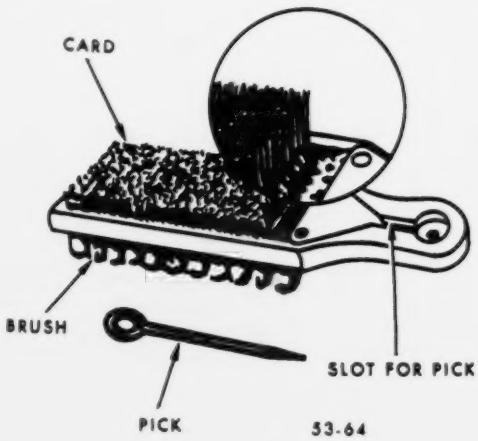

Figure 3-40. File card.

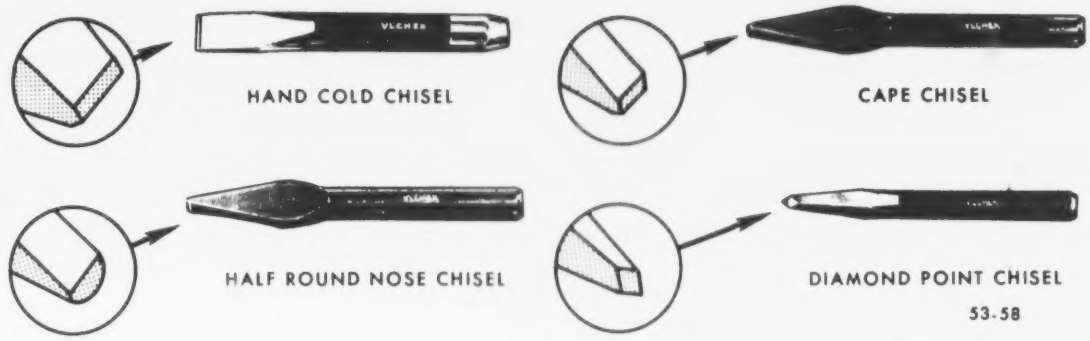

Figure 3-41. Types of chisel.

These blades are identified by the length of blade and the number of teeth per inch (or pitch).

Blade selection. Blades with 14, 18, 24, and 32 teeth per inch are available. Blades are made of high-grade tool steel, which may be flexible or all-hard. In flexible blades, only the teeth are hardened. Blade selection involves finding the right type for the job to be done, as illustrated in figure 3-46. An all-hard blade is best suited for sawing brass, tool steel, cast iron, and heavy cross sections of material. Flexible blades are recommended for sawing hollow shapes and material having a thin cross section.

The selection of teeth is important. A blade with 14 teeth per inch is recommended for cutting cold roll and structural steel. The 18 teeth per inch blade is recommended for solid stock aluminum and cast iron. The 24 teeth per inch blade is recommended for cutting thick wall tubing, pipe, channel iron, and angle iron, as well as brass and copper. The blade you will most often use is the 32 teeth per inch, which is recommended for thin wall tubing and light gage sheet stock.

Set selection. Although it is not important to the selection of proper blades, since you have no real choice in the matter, you should have some understanding of the term "set." The teeth of all hacksaw blades are set to provide clearance for the rest of the blade in the saw cut. You will notice, if you look at all the hacksaw blades in your tool kit, that the blades with coarse teeth have one tooth moved slightly to the right, the next one to the left, the third one to the right, etc. This is the standard or alternate set. Medium coarse teeth may be bent in a raker set (one right, one left, one straight, etc.), while fine-toothed blades usually have a wave or undulated set wherein whole sections of teeth are alternately bent to the right or left. Figure 3-47 shows the three types of sets. Carpenters must sharpen and reset the teeth of their wood-cutting saws from time to time; but when your hacksaw doesn't seem to cut as well as it used to or seems to bind excessively from lack of sufficient set, you should merely discard that blade and insert a new one.

You do not have to worry about any choice of proper set because that factor is governed automatically by the coarseness of the teeth at the time the blade is manufactured. However, your judgment in selecting a blade with proper pitch (number of teeth per inch) may well determine how quickly and easily the saw cuts through the material and how long the blade remains serviceable.

Frame selection. Although the solid frame is stronger, as shown in figure 3-45, it holds only one particular length of blade. The adjustable frame, on the other hand, accommodates blades 8, 10, or 12 inches in length (as measured between centers of the stud pin holes). In either case, you mount the blade on pins located in sliding studs at each end of the frame. These free-sliding studs provide a means of setting the blade at a 90° angle to the normal position in order to avoid interference from the frame when making long cuts. In the straight-handle type of frame you tighten the blade by twisting the handle clockwise. In the pistol-grip type, adjust the blade tension by turning the wing nut located at the far end of the frame.

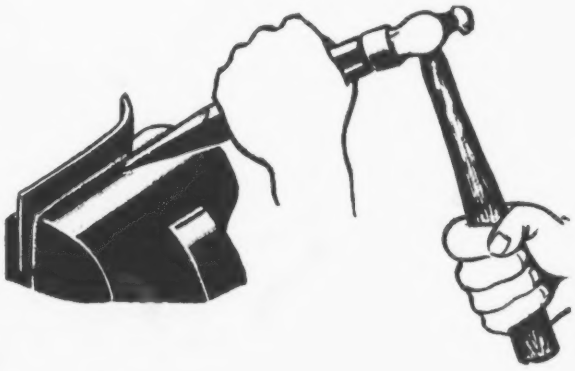

Figure 3-42. Correct use of a chisel.

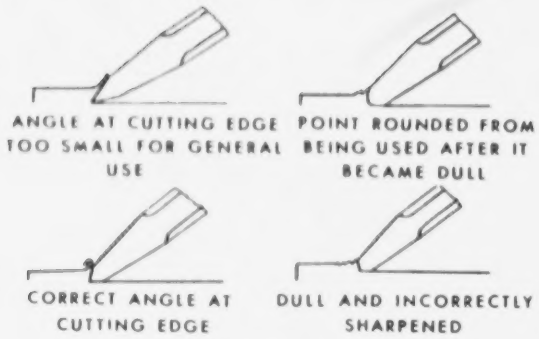
ANGLE AT CUTTING EDGE TOO SMALL FOR GENERAL USE
POINT ROUNDED FROM BEING USED AFTER IT BECAME DULL
CORRECT ANGLE AT CUTTING EDGE
DULL AND INCORRECTLY SHARPENED
53-728

Figure 3-43. Results of correct or incorrect sharpening.

Tighten the frame enough to prevent the blade from buckling and drifting, but do not tighten it so much that you break the blade, shear the pins, or bend the frame. If the blade begins to lean to one side, you are tightening the frame too much. When you install a blade on the frame, always remember to install the blade with the angles of the teeth forward (away from the handle).

Procedures. When using a hand saw, you obtain best results if you clamp the material to be cut in a vise in such a way that it provides as much bearing surface as possible and engages the greatest number of teeth on the blade. Indicate the starting point by nicking the surface of the material to be cut with the edge of a file to break away any sharp corner that might tend to strip the teeth. This mark also aids in starting the saw at the proper place. Hold the saw at an angle that keeps at least 2 teeth in contact with the work at all times. Start the cut with a light, steady, forward stroke just outside the cutting line. At the end of the stroke, relieve the pressure and draw the blade back. (The cut is made on the forward stroke.) Figure 3-48 illustrates the correct and incorrect positioning of solid stock for proper bearing surfaces.

After the first few strokes, make each stroke as long as the hacksaw frame allows. This prevents the blade from overheating. Apply just enough pressure on the forward stroke to cause each tooth to remove a small amount of metal. The strokes should be long and steady with a speed of not more than 40 or 50 strokes per minute.

Figure 3-44. Care of chisels.

Exercises (242):

1. You must cut some solid stock aluminum. What type and pitch of blade do you use?

2. What is the recommended pitch for cutting thin wall tubing?

3. Why is it necessary for a hacksaw blade to have "set"?

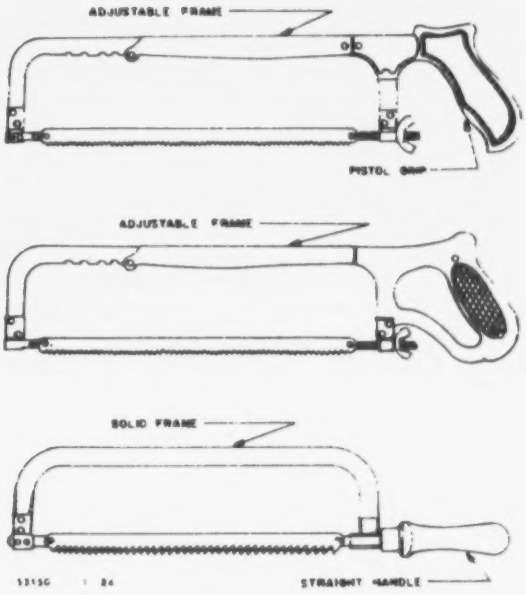

Figure 3-45. Types of hacksaw.

4. You must cut a 12-foot length of angle iron into 12 equal sections. Which blade pitch would give the best results?

5. How can you position stock to obtain the best results when using a hacksaw?

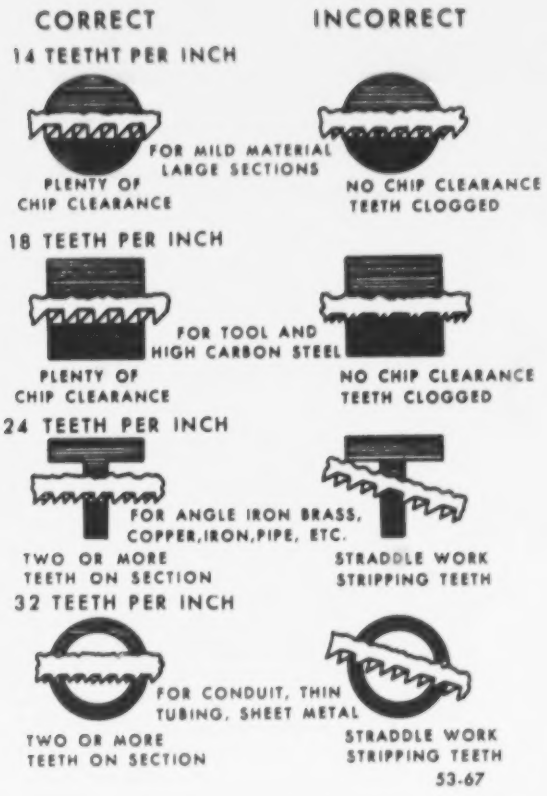
CORRECT
INCORRECT
14 TEETHT PER INCH
FOR MILD MATERIAL LARGE SECTIONS
PLENTY OF CHIP CLEARANCE
NO CHIP CLEARANCE TEETH CLOGGED
18 TEETH PER INCH
FOR TOOL AND HIGH CARBON STEEL
PLENTY OF CHIP CLEARANCE
NO CHIP CLEARANCE TEETH CLOGGED
24 TEETH PER INCH
FOR ANGLE IRON BRASS, COPPER,IRON,PIPE, ETC.
TWO OR MORE TEETH ON SECTION
STRADDLE WORK STRIPPING TEETH
32 TEETH PER INCH
FOR CONDUIT, THIN TUBING, SHEET METAL
TWO OR MORE TEETH ON SECTION
STRADDLE WORK STRIPPING TEETH
53-67

Figure 3-46. Correct sawtooth selection.

6. Which stroke (forward or backward) is the cutting stroke?

7. Name the three types of blade set.

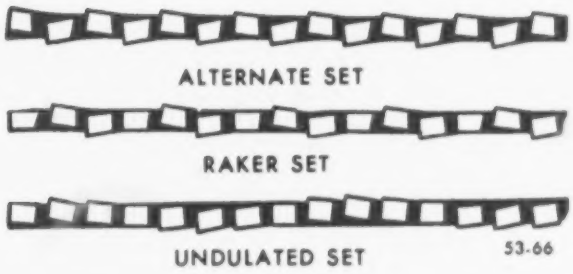

Figure 3-47. Set of hacksaw blade teeth.

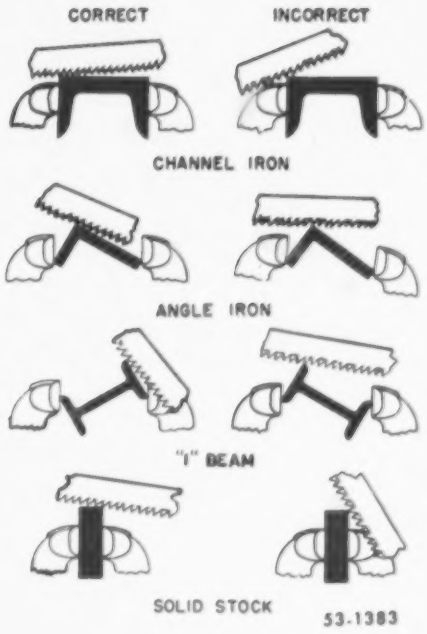

Figure 3-48. Bearing surfaces.

Layout Techniques

CAN YOU BUILD anything with exact measurement without using a drawing of some kind? No one can. The drawing may be a simple shop sketch or a sophisticated mechanical drawing, but it is an absolute essential to good fabrication procedures.

We start off this chapter with a review of the fundamentals of working with fractions and decimals, since almost all the measurements you'll work with will be one or the other. From there, we cover a brief introduction to the metric system. The conversion to the metric system has started, and in the not too distant future, the Air Force will be using the metric system in all its measurements. Finally, in later portions of this chapter, we discuss factors related to drawings including terms, dimensioning procedures, types of drawings, and drawing construction.

4-1. Fundamentals of Shop Mathematics

The actual measurement of many of the quantities we have to deal with in the shop naturally involves more than just whole numbers alone. All of us see such familiar measurements as 24½ lbs on a sack of flour, the stroke if a gasoline engine listed as 3⅜ inch, savings bank interest of 1½%, and many more too numerous to list. It is very important that all airframe repairmen be able to use these fractional parts of numbers in all mathematical operations as easily and accurately as they use whole numbers. So let's begin with a review of common fractions and their application to many airframe shop problems.

243. Given situations, add, subtract, divide, and multiply fractions and convert common fractions to decimals.

Definitions. Before we get into the rules and the actual mechanical operations of shop mathematics, let's make sure you know certain terms and their definitions; without them, you might be spinning your wheels.

Fraction. A *fraction* is a number which shows what number of equal parts of a unit is taken, as ¼, 7/32, or 9/16. Thus ¼ shows that three of the four parts of a unit are taken; 7/32 shows that seven of the thirty-two parts are taken.

Terms. The *terms* of a fraction are the *denominator* and the *numerator.*

Denominator. A *denominator* is the number which shows into how many equal parts the unit has been divided. The denominator is, of course, written below the line.

Numerator. The *numerator* is the number which shows how many equal parts of the unit have been taken to make a fraction. The numerator is written above the line.

Common fraction. A *common fraction* is a fraction which has both terms (numerator and denominator) expressed. (Contrast this with *decimal fraction,* covered later.)

Proper fraction. A *proper fraction* is one whose numerator is less than its denominator, as; ⅜, 5/16.

Improper fraction. An *improper fraction* is one whose numerator is larger than the denominator, as: 8/3, 16/5.

Mixed number. A *mixed number* is a number composed of an integer and a fraction taken together; as, 3¼, 7½.

Reducing Common Fractions. The fundamental rule is that the value of a fraction is not changed by multiplying the numerator and denominator by the same quantity. The value of a fraction is not changed by dividing the numerator and denominator of a fraction by the same number.

Example:

$$\frac{1}{2} = \frac{1}{2} \times \frac{4}{4} = \frac{4}{8}$$

$$\frac{8}{12} = \frac{8 \div 4}{12 \div 4} = \frac{2}{3}$$

When both numerator and denominator cannot be divided by the same number, the fraction is said to be in lowest terms. An improper fraction may be reduced to a mixed number by dividing the numerator by the denominator.

$$\frac{95}{8} = 95 \div 8 = 11\frac{7}{8}$$

Adding Common Fractions. There are three basic rules to follow when adding fractions. Use the following methods when applying the rules for adding fractions.

Rule one. Fractions cannot be added or subtracted unless they have a common denominator. Fractions have a *common denominator* when all their denominators are the same; as ⅜, ⅞, and $^{12}⁄_{8}$. In adding fractions, select the *least common* denominator. This is the lowest denominator into which all the denominators will divide evenly.

To reduce the fractions to the least common denominator, divide the least common denominator by the denominator of each fraction, and multiply both terms of the fraction by the quotient.

Example: Express ⅔, ¾, and ½ as fractions with a common denominator.

The lowest number into which the denominators 3, 4, and 2 will divide is 12; therefore, 12 is the least common denominator. By means of rule 1, then, the fractions are reduced to the least common denominator as follows: ⅔ = $^{8}⁄_{12}$, ¾ = $^{9}⁄_{12}$, and ½ = $^{6}⁄_{12}$.

Rule two. In the second rule; to add fractions, first reduce them to a common denominator; then add the numerators and write their sum over the common denominator. If the result is an improper fraction, reduce it to a mixed number and reduce the fractional part to its lowest terms.

Example:

Add ½, ¾, and $^{5}⁄_{12}$

Solution:

½ = $^{6}⁄_{12}$
¾ = $^{9}⁄_{12}$
$^{5}⁄_{12}$ = $^{5}⁄_{12}$
$^{20}⁄_{12}$ = 1$^{8}⁄_{12}$ = 1⅔

Rule three. In the third rule; to add whole and mixed numbers, add the whole numbers and the fractions separately and then add the results.

Example:

Add 12¼, 14⅜, and 7$^{5}⁄_{16}$

Solution:

12¼ = 12$^{4}⁄_{16}$
14⅜ = 14$^{6}⁄_{16}$
7$^{5}⁄_{16}$ = 7$^{5}⁄_{16}$
33 $^{15}⁄_{16}$ = 34$^{-1}⁄_{16}$

Subtracting Common Fractions. To subtract fractions, first reduce fractions to the least common denominator and subtract the numerators as in the subtraction of integers. Write the difference over the least common denominator. Reduce the resulting answer to lowest terms.

Example:

Subtract ¼ from ⅞

Solution:

⅞ = ⅞
¼ = $^{2}⁄_{8}$
⅝

Example:

Subtract 2$^{5}⁄_{16}$ from 4$^{19}⁄_{32}$

Solution:

4$^{19}⁄_{32}$ = 4$^{19}⁄_{32}$
2 $^{5}⁄_{16}$ = 2$^{10}⁄_{32}$
2 $^{9}⁄_{32}$

Multiplying Common Fractions. To multiply two or more fractions together, multiply the numerators together and multiply the denominators together. Write the product of the numerators over the product of the denominators. Reduce the resulting fraction to lowest terms.

Example:

Multiply ¾ by ⅝

Solution:

Multiply numerators together

$$\frac{3 \times 8}{4 \times 9} = \frac{24}{36} = \frac{2}{3}$$

This answer could have been obtained much more easily by the method of cancellation. Cancellation consists of striking out the factors that are common to both numerators and denominators of the given fraction.

Example:

Multiply ¾ by ⅝

Solution: Solve by cancellation.

$$\frac{3 \times 8}{4 \times 9}$$

By cancellation, both numerator and denominator can be divided by 3 to get 1 in the numerator and 3 in the denominator.

$\frac{1}{4} \times \frac{2}{3} =$

By dividing by 4, we get 2 in the numerator and 1 in the denominator.

$\frac{1}{1} \times \frac{2}{3} =$

Multiply the new numerators together to get 2 and multiply the new denominators together to get 3.

$$\frac{1 \times 2}{1 \times 3} = \frac{2}{3}$$

Dividing Common Fractions. To divide common fractions, invert the divisor and multiply. When a fraction is inverted, the numerator becomes the denominator; and the denominator becomes the numerator. After inverting the divisor, change the division sign to multiplication and solve the problem.

Example: Divide $\frac{5}{7}$ by $\frac{3}{4}$.

Solution: Invert the divisor $\frac{3}{4}$; therefore, the divisor becomes $\frac{4}{3}$ when inverted. After inverting, change the division sign to multiplication and solve.

$\frac{5}{7} \times \frac{4}{3} = \frac{20}{21}$

Converting a Common Fraction to a Decimal. The word *decimal* is usually short for *decimal fraction*. In a decimal fraction, only the numerator is expressed. To convert a common fraction to a decimal, you must remember that the line between the numerator and denominator indicates division.

Example:

$\frac{7}{8}$ means 7 divided by 8. ($8\overline{)7}$)

You place a decimal point after the 7 (since 8 does not go into 7), add three zeros, and then carry out the division. Place the decimal point in the answer directly over the decimal point, as shown in the example below.

```
   .875
8| 7.000
   64
   60
   56
    40
    40
```

The quotient is a decimal fraction. The numerator is 875, and is expressed. The denominator is 1000, and is only implied. ($.875 = \frac{875}{1000}$)

Exercises (243):

Record ONLY the final answers, not the step-by-step procedures, for the following fraction problems. (But use scratch paper if you like.)

1. Reduce to halves: $\frac{2}{4}$; $\frac{8}{16}$.

2. Reduce to lowest terms: $\frac{4}{8}$; $\frac{9}{64}$.

3. Find the sum of: $\frac{1}{2} + \frac{2}{3}$; $\frac{5}{6} + \frac{3}{8}$.

4. Find the difference: $\frac{2}{3} - \frac{1}{2}$; $\frac{23}{32} - \frac{3}{8}$.

5. Multiply: $\frac{1}{2} \times \frac{1}{8}$; $\frac{3}{4} \times \frac{3}{5}$.

6. Divide: $\frac{9}{16} \div \frac{3}{4}$; $\frac{9}{64} \div \frac{3}{32}$.

7. Convert the following fractions to decimals:
   a. $\frac{3}{32}$

   b. $\frac{3}{4}$

244. Given data, add, subtract, divide, and multiply decimal fractions and convert decimals to common fractions.

Decimals. A decimal is a fraction whose denominator is 10 or some power of 10; as 100, 1000, etc. We call $\frac{7}{10}$, $\frac{39}{100}$, $\frac{452}{1000}$, fractions.

Since the denominator of a decimal is always 10 or a power of 10 or since the denominator is always a 1 with zero attached, we can write a decimal by omitting the denominators entirely.

Example:

$\frac{7}{10}$ is written .7
$\frac{39}{100}$ is written .39
$\frac{452}{1000}$ is written .452

You can distinguish the decimal .7 from the whole number 7 by placing a period (.) in front of the 7. This period is called the decimal point. Any number, therefore, with a decimal point in front of it is a fraction

whose numerator is the number after the point and whose denominator is a 1 with as many zeros as there are figures in the number to the right of this point.

Example:

.7 means $^{7}/_{10}$; .39 means $^{39}/_{100}$; .07 means $^{7}/_{100}$; .007 means $^{7}/_{1000}$, etc.

The following table indicates the relative value of the same digits when pointed off by various locations of the decimal point from left to right.

700. = seven hundred
70. = seventy
7. = seven
.7 = seven tenths
.07 = seven hundredths
.007 = seven thousandths
.0007 = seven ten thousandths

Adding and Subtracting Decimals. When adding decimals, arrange the given numbers so that the decimal points are in a column, as shown in example I below. To avoid errors, add zeros to the numbers with the fewer places, as in example II, so that the numbers will have an equal number of places after the decimal points. Then proceed as in addition of ordinary whole numbers and place the deimal point in the sum, in the same column as the other decimal points.

Example I:

3.25
72.004
864.0725
647.
.875

Example II:

3.2500
72.0040
864.0725
647.0000
.8750

When subtracting decimals, write the numbers so that the decimal points are under each other. Be sure that the subtrahend (smaller number) is under the minuend (larger number), as shown in example I below. Add zeros to one number if it has fewer figures after the decimal point than the other. (In example II, we added a zero after the 3 in the minuend.) Then proceed as in the subtraction of whole numbers. Place the decimal points in the difference under the other decimal points.

Example I:

42.63 (minuend)
18.275 (subtrahend)

Example II:

42.630
18.275

Multiplying Decimals. When multiplying decimals, you multiply the same as you would with whole numbers, as in the example.

Example:

43.286 (multiplicand)
6.04 (multiplier)
173144
2597160
261.44744 (product)

To locate the decimal point in the product, begin at the right and point off the product as many decimal places as there are decimal places in both the multiplier and the multiplicand. In the problem above, the multiplicand has 3 places after the decimal point while the multiplier has 2, making a total of 5 places; therefore the product must have five decimal places.

Dividing Decimals. When dividing decimals, place the dividend (the number being divided) inside the box and place the divisor (the number you are dividing by) outside the box.

(divisor) $.964\overline{).78}$ (dividend)

Convert the divisor into a whole number by moving the decimal point to the right 3 places, then move the decimal point in the dividend an equal number of places to the right. When the dividend has fewer figures than the divisor, add zeros.

Place the decimal point in the quotient directly above the decimal point in the dividend. Since the quotient is not an even whole number, add zeros after the decimal point in the dividend and continue the division to as many decimal places as is required.

.809 (quotient)
964)780.000
771 2
8 800
8 676
124

Converting a Decimal to a Common Fraction. The rule to remember when converting a decimal to a common fraction is: The number after the decimal point is the numerator of the fraction, and the denominator is a 1 with the same number of zeros after it as there are figures to the right of the decimal point.

Let's convert the decimal .375 to a common fraction. The numerator is 375. The denominator is 1 with three zeros, because there are three figures to the right of the decimal point. Therefore, the denominator is 1000. Remember, always (if possible) reduce the fraction to its lowest term.

Example:

$.375 = {}^{375}/_{1000} = {}^{3}/_{8}$

Exercises (244):

Record ONLY the final answer, not the step-by-step procedures, for the following decimal problems.

1. Solve: 283.5 + 69.2; 0.067 + 37.762 + 762.37 + 7.9.

2. Solve: From 685.57, take 2.4; take .00852 from 1.70853.

3. Multiply: 2 × 1.5; .375 × .875.

4. Divide: 12 ÷ 1.5; .0021 ÷ .007.

5. Convert the following fractions to decimals:
   a. .25
   b. .875

4-2. Introduction to the Metric System

Since most of the world uses the metric system, the United States has decided to convert to the metric system by 1980. Of course, if you are stationed outside of the United States, you may aleady have a working knowledge of the metric system. As a member of the Air Force, you must know the metric system by 1980—so let's get a head start.

245. Answer questions on the history of the metric system and its future importance to the Air Force.

Man has realized for thousands of years that he must have a system of weights and measures. The attempt to establish uniform standards has posed unsolvable problems for rulers and leaders since before recorded history. Now, the world has two principal standards: the metric and the English. The relationship of the English system to the metric system has been established; but because of fundamental differences in the structure of the two systems, problems still exist.

Problems of Measurements. If you had gone shopping in England long ago and brought home a blind, a bing, a fatt, a flyke, a shid, and a swod, do you know what you would bring home? You would have 250 eels, 8 hundredweight of lead, 4 bales of unbound books, a side of bacon, 4 feet of firewood, and a bushel of fish. These were ancient weights and measures in the British Isles. They also had their nooks and glews, but these were units of land. (A nook was 20 acres, and a glew was 25 herrings.) Throughout history, man has used hundreds of different weights and measures. However, to be effective, a standard must be known to everyone. Although this seems simple to us, it is a problem that vexed leaders of countries for hundreds of years. The problems of communication and language, along with man's instinct to try to do as well for himself as possible, made standards of weights and measures over large areas impossible.

The use of parts of the body as a standard of measurement can be traced to the beginning of history. It was natural for man to use natural units of length such as the palm, the breadth of four fingers (about 3 inches) the span, the distance covered by the spread hand (9 inches), the foot (12 inches) the cubit, from the elbow to the tip of the middle finger (18 inches), the yard, measured from the center of the body to the finger tips outstretched arm (36 inches), and the fathom, spanned by the extended arms (72 inches). By the time the pyramids were built, builders and designers had precise standards and were able to use them with great skill. For example, the base of the Great Pyramid at Giza is 500 cubits long (18.24 inches equals 1 cubit). The length of the base is 760 feet, and the perimeter of the base is 3,040 feet. This is one half of 6,080 feet—one of the values of the meridian mile—or one sixtieth of the degree of the earth's meridian.

Even though the foot (12 inches) is naturally divisible by 2, 3, 4, and 6—twice the number of divisors of 10—and the multiplicity of units makes it easy to use small numbers, the foot is part of the English system of measure, which has some serious defects. The relationship between linear measures and those of weight and capacity are purely arbitrary; that is, there is no relationship between feet and gallons. Further, since 1893, the United States has had no official yard bar or pound weight. Our fundamental national standards are the meter and the kilogram.

The Meter and the Kilogram. In 1790, a strong and able leader in the French National Assembly, Charles-Maurice Talleyrand, proposed that the Academy of Sciences be instructed to study a universal system of weights and measures for France. The Assembly passed a decree to that effect. The French committee spent much time debating the basis for a fundamental unit. Three units from nature were considered: the second's pendulum, the section of an arc of the equator, and a section of an arc of a meridian. The pendulum was not accurate enough, so the committee decided upon a terrestrial arc which they believed was not only uniform but universal. Either the equator or a meridian would do as a basis, but they chose a meridian because it would be easier to survey. The Assembly proposed a survey along a meridian from Dunkirk on the English Channel to Barcelona on the Mediterranean; an additional advantage was that both cities are at sea level. The linear standard of the new system was to be one ten-millionth of the meridian distance between the pole and the equator as determined by this survey. The survey took

7 years to complete. The Assembly, after making the survey and deciding on the weights and measures, decided that Greek prefixes would be used to denote multiples of it and that Roman prefixes would be used to denote subdivisions. For ease of conversion, multiples and subdivisions were based on 10. The Assembly then constructed a standard for the meter, a platinum bar measuring 39.2046 American inches.

A platinum standard weight, the kilogram, equal to 2.2046 American pounds was made, and the meter bar and the kilogram were deposited in the Archives in Paris in 1799. The committee based other standards upon the meter. For example, the liter is the measure of capacity for both liquids and dry materials; its volume is the same as that of a cube of one tenth of a meter on each side. The gram is the absolute weight of a volume of pure water occupying a volume equal to a cube of one-hundredth part of a meter on each side and at the temperature of melting ice. These were then the only legal systems of weights and measures in France.

In 1870, the French government invited other nations to a conference on metric standards. Fifteen nations attended, including the United States. This conference led to the signing in 1875 of the "Metric Convention," a treaty under which an International Bureau of Weights and Measures was established. In 1866, the metric system became the only system legally recognized by the United States. Our own units have never been given similar Congressional recognition. They rest on a foundation of state laws. Since 1893, the United States has had no official national standard yard bar or pound weight. Our fundamental national standards are the meter and the kilogram.

The Future Importance of the Metric System to You and the Air Force. Over 90 percent of the world is using the metric system. With the British decision in 1965 to convert to the metric system by 1975, the United States is the only major Nation in the world still using the English system. This has created problems in trade, communications, and for the military has resulted in a policy of all arms and related systems being built to metric specifications. Most of us have seen the problem in a form we recognize, when we have to repair a German car or Japanese motorcycle. For us, the answer might be a few dollars for metric wrenches. However, to convert from the English system to the metric system will cost the United States billions of dollars. This will be a one-time expense, and it will never be any cheaper, so the United States has decided to change to the metric system by 1980.

The metric system will soon be in wide use in the United States. We must know the system and how to use it. Conversion from one system to the other will be necessary for several years during the transition period. Military personnel will be involved in the use of the metric system at home; and if you go outside the continental United States, a basic knowledge of the metric system will be useful. Your early acceptance of the program will make the transition easier for you and the Air Force.

Exercises (245):

1. What are the legally recognized standards of weights and measures in the United States?

2. Why is the metric system easy to use when converting from one reference to another?

3. What country developed the metric system?

4. The man who proposed that the Academy of Sciences be instructed to study a universal system of weights and measures for France was _____ _____ .

5. Britain converted to the metric system by ____ .

6. What problems are created by the United States using the English system?

7. By what year is the United States going to change to the metric system?

246. Describe the basic system for constructing unit names in the metric system, and match metric prefixes and abbreviations with their meanings.

It is not the intent of this lesson to familiarize you with the entire metric system and its uses but rather to give you a working knowledge of the fundamentals of the system and common expressions used. As the United States continues to implement the metric system, more advanced courses will be presented. Our approach to the subject is the teaching of the metric system, rather than conversion from the English system of measurement. Comparisons between the two systems is necessary in some cases to provide a common ground for understanding by relating the known to the unknown.

Metric Roots and Prefixes. Under the English system of measurement, we normally use yards, pounds, and quarts for measuring length, weight, and volume capacities. When using the metric system, length is expressed in meters, weight is expressed in grams, and liquid capacity is expressed in liters. (See

fig. 4-1.) The terms meter, gram, and liter are root words. When a prefix is added, it indicates the multiple or fraction of the measure indicated by the root word.

The key to understanding the metric system lies in the prefixes that describe units of measurement built upon the basic units of meter, gram, and liter.

These prefixes are (STUDY THIS LIST):

a. deci (DESS-see)
b. centi (SEN-ee)
c. milli (MILL-lee)
d. micro (MY-crow)
e. deca (DECK-a)
f. hecto (HECK-toe)
g. kilo (KEY-lo)
h. mega (MEG-a)

Values of the metric prefixes can be placed in two categories—those that make smaller units and those that make larger units. The value for smaller units are:

a. deci = $\frac{1}{10}$ or .1

b. centi = $\frac{1}{100}$ or .01

c. milli = $\frac{1}{1000}$ or .001

d. micro = $\frac{1}{1000000}$ or .000001

Metric prefixes used for making larger units are:

a. deci = $\frac{1}{10}$ or .1
b. centi = $\frac{1}{100}$ or .01
c. milli = $\frac{1}{1000}$ or .001
d. micro = $\frac{1}{1000000}$ or .000001

Note that *most* of the prefixes that make the root smaller end in *i*. The prefixes that make the root larger end in *o* or *a*. For common usage you would seldom use micro, mega, and deca. Micro and mega are used more in scientific field and deca is more commonly called 10; i.e., 1 decameter equals 10 meters; therefore, it is common usage to say 10 meters rather than 1 decameter.

Units of Distance. Let's take a look at the small distances first—those we're most accustomed to measuring. In the metric system, the distances between a tenth of an inch and a few yards are commonly expressed in three ways: millimeters, centimeters, or in decimal parts of a meter. Like the English system, the metric system has subunits of measurement for each basic unit. The English yard is divided into feet, inches, and fractions of an inch. The metric meter is divided into millimeters, centimeters, and decimeters. In normal measurements around the house or work area, the centimeter is the most commonly used unit. Remember, a millimeter is equal to a tenth of a centimeter and a thousandth of a meter. As a rule of thumb, *a meter is about 10 percent larger than an English yard.*

Using multiples of 10s, the next unit of length is 10 meters or 1 decameter, ten decameters equal 1 hectometer, and 10 hectometers equals 1 kilometer. A kilometer is much shorter than a mile.

Units of Volume. Metric measures for volume are somewhat simpler than our system in that one set of units is used for both liquid and dry measures. The metric system uses three main units to measure volume: liter, milliliter, and cubic meter.

The liter is the most common unit of volume; it is only 5 percent smaller than the quart. By definition, 1 liter equals 1 cubic decimeter. Some of the more familiar items measured or sized in liters are milk packaged in 1-, 2-, or 4-liter containers, and beer and soft drinks, packaged in half-liter cans. We can expect the 5-gallon gas can to become a 20-liter can.

A liter of dry measure is the same volume as a liter of liquid measure. A quart of strawberries will just about fill a liter box, and a "peck" of potatoes may be packaged in an 8-liter box. Larger dry measurements will soon be packaged in fractions of a cubic meter or in whole cubic meter containers. The milliliter, reserved for much smaller measures of volume than the liter, is one-thousandth of a liter and is equal to one cubic centimeter. Remember, both liquid and dry measures are expressed as liters, milliliters, or cubic meters.

Units of Mass. There are actually four major metric units of mass: the milligram, the gram, the kilogram, and the metric ton. The milligram is so light (a grain of sugar weighs about 1 milligram) that it is used in medicine and other scientific areas.

The two units of weight commonly used every day are the gram and kilogram. Most dry-packaged goods such as breakfast cereals, rice, etc., are measured in grams. Most canned goods are also measured in grams. Larger items like meat are measured in kilograms. One kilogram equals 2.2 pounds. Suppose you wanted a 4½-pound rib roast. Using the metric system, you would ask for a two-kilogram roast. Remember, there are 1,000 grams in 1 kilogram. If you want 250, 500,

Figure 4-1. Metric divisions.

or 750 grams of a given item, you would normally ask for:

a. One quarter kilogram for 250 grams.
b. One half kilogram for 500 grams.
c. Three quarters kilogram for 750 grams.

The weight of 1 gram is defined as the weight of 1 cubic centimeter of pure water. Weights less than ¼ kilogram are expressed in so many grams; i.e., 5, 10, or 20 grams. Our present 1-ounce container of pepper weighs 28 grams.

For many years, the Maritime Service has used the long ton to compute cargo tonnage for ships. The long ton is 2,200 English pounds which is equivalent to one metric ton.

Temperature. You are all familiar with the Fahrenheit scale developed by Gabriel Fahrenheit. Using the Fahrenheit scale, water freezes at +32° F and boils at +212° F. Shortly after Fahrenheit's scale was adopted, Anders Celsius, a Swede, developed a scale on which zero is the freezing point of water and 100° the boiling point. Celsius' scale was adopted by science and the metric system because of the convenience of the scale. It was popularly called the "centigrade" scale because of its range from 0 to 100, but it is still officially the Celsius scale—° C after Anders Celsius.

Knowing the two ends of the Celsius scale (0° C and 100° C), let's take a look at some of the ambient temperatures and their reference points. A room at a normal temperature of 68° F is at 20° C. You would probably want the air conditioner set at 26° C.

Metric Abbreviations. The metric measurement system has developed abbreviations for its units just as the English system has. The metric system provides a very logical approach to abbreviations based on the prefix and basic unit of measurement. A fairly complete list of the metric units and their abbreviations is shown in figure 4-2.

Exercises (246):

1. In the metric system, what are the basic units of length, weight, and volume?

METRIC SYSTEM

LENGTH — UNIT (abbr.)	NUMBER OF UNITS	APPROXIMATE U.S. EQUIVALENT
myriameter (mym)	10,000	6.2 miles
kilometer (km)	1,000	0.62 mile
hectometer (hm)	100	109.36 yards
decameter (dam/dkm)	10	32.81 feet
meter (m)	1	39.37 inches
decimeter (dm)	0.1	3.94 inches
centimeter (cm)	0.01	0.39 inch
millimeter (mm)	0.001	0.04 inch
AREA		
square kilometer (sq km or km^2)	1,000,000	0.3861 square mile
hectare (ha)	10,000	2.47 acres
are (a)	100	119.60 square yards
centare (ca)	1	10.76 square feet
square centimeter (sq cm or cm^2)	0.0001	0.155 square inch
CAPACITY		
kiloliter (kl)	1,000	1.31 cubic yards
hectoliter (hl)	100	3.53 cubic feet 2.84 bushels
decaliter (dkl)	10	0.35 cubic feet 1.14 pecks 2.64 gallons
liter (l)	1	61.02 cubic inches 0.908 quart 1.057 quarts
deciliter (dl)	0.10	6.1 cubic inches 0.18 pint 0.21 pint
centiliter (cl)	0.01	0.6 cubic inch 0.338 fluidounce
milliliter (ml)	0.001	0.06 cubic inch 0.27 fluidram
MASS & WEIGHT		
metric ton (MT or t)	1,000,000	1.1 tons
kilogram (kg)	1,000	2.2046 pounds
hectogram (hg)	100	3.527 ounces
decagram (dkg)	10	0.353 ounce
gram (g or gm)	1	0.035 ounce
decigram (dg)	0.10	1.543 grains
centigram (cg)	0.01	0.154 grain
milligram (mg)	0.001	0.015 grain

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Figure 4-2. Metric units of measurement.

2. What two basic parts make up the names for units of metric measurements?

3. Which of the two parts (referred to above) is the key to understanding the metric system?

4. Why is the Celsius scale preferred over the Fahrenheit scale?

5. Match the prefixes listed in column A with their corresponding value in column B.

Column A		*Column B*
1. milli	= _____	a. 1/100
2. centi	= _____	b. 1/10
3. deci	= _____	c. 10
4. deca	= _____	d. 1,000
5. hecto	= _____	e. 1/1000
6. kilo	= _____	f. 100

6. Match the abbreviations in column A with the correct term shown in column B.

Column A		*Column B*
1. kg	- _____	a. millimeter
2. C	- _____	b. centiliter
3. t	- _____	c. kilogram
4. cl	- _____	d. milligram
5. mm	- _____	e. metric ton
6. mg	- _____	f. Celsius

4-3. Interpretation of Drawings and Blueprints

Webster defines drawing as "the art or technique of representing an object or outlining a figure, plan, or sketch by means of lines." In this simple definition, you can see why you have drawings—to outline a figure, plan, or sketch. The result tells you what is required and what the finished product will look like.

Drawings, as we use it, is a method of conveying ideas concerning the construction or assembly of objects. This is done with the help of lines, notes, abbreviations, and symbols. It is very important that you understand the meaning of the different lines, notes, abbreviations, and symbols used in drawings.

247. State the correct fundamental terms and definitions of terms used in drawings.

Descriptive Terms. To convey an accurate description of an object by using a drawing, the person describing the object and the one for whom the description is made must use uniform definitions of terms. The following explanations are given to help you understand the terms in this chapter.

Length. A straight line is the shortest distance between two points. Length is the distance between two end points of a line. In drawing, this term usually refers to the longest horizontal dimension of a plane figure. For example, figure 4-3 shows a board, lying in a horizontal plane, to which a cleat has been attached. The length of the board is 24 inches and the cleat is 18 inches in length. In both cases, the length is the greatest dimension lying in the same plane of the object. Dimensions for squares or equal-sided figures are excepted since all sides are equal.

Width. The term "width" usually refers to the least dimension of a plane surface at right angles to the length and in the same plane. In figure 4-3 the board is 18 inches in width, and the cleat is 3 inches in width.

Thickness. This term is used for the third dimension of solid objects such as boards or sheets of material. Remember that this term can mean depth and can apply either to the main part of the object or to some separate part attached to the object being described. It can also apply to a part projecting from the object.

Height. This term is used to identify the vertical dimension of a plane figure lying in a vertical plane. It is the shortest distance from the base, or reference point, to another point perpendicular to the reference point. For example, if you place a block upon a table, the height is the length of a perpendicular line from the surface of the table to the highest point of the object. Instead of referring to this dimension as length, one would refer to it as the height of the block. In figure 4-3 the block is 3 inches high—that is, its top is 3 inches above its base or above the surface on which it stands.

Depth. Depth, like thickness, is used as a third dimension of a solid measured from the surface viewed to a point or plane away from the viewer such as top to base or front to back. Note, in figure 4-3, the drawing of a block with a groove in the top. We would say this groove is ½ inch in depth, meaning that it extends ½ inch below the top surface of the block.

Exercises (247):

1. What is the longest dimension of a plane figure lying in the same horizontal plane called?

2. What is the longest dimension of a plane surface at right angles to the longest dimension called?

3. What term refers to the longest perpendicular distance from the base plane of an object to the top of the object?

4. Which descriptive term is the opposite of the term "height"?

248. Select or name the correct drawing line for each given description.

Lines and Their Uses. Your ability to read this printed page depends upon your skill in recognizing the characters of the alphabet. In addition to recognizing these characters, you must know how they are used in the construction of words and sentences. Likewise, being able to read drawings and blueprints depends upon your ability to recognize the character of the lines used in making drawings and to understand how they fit into the description of objects represented. Because of their fundamental importance, these lines are called the alphabet of lines.

Visible outlines. In a drawing which describes an object, the outline of all faces is represented by lines. The surfaces visible to the eye are always outlined in solid lines, which are the most important in the alphabet of lines. Being bold, solid lines, they become the basis for comparison of the weights of all other lines. Notice the weight of this line about midway down in figure 4-4. How visible outlines are used is shown in figure 4-5. (As we discuss the types of lines, check figure 4-4 to see the line; then look at the appropriate figure to see how the line is used.

Invisible outlines. Surfaces that are invisible, or hidden, are always outlined by using dashed lines, called *invisible lines.* They consist of a series of short dashes of medium weight, about half as heavy as the lines used to indicate visible surfaces (see fig. 4-4). In the reading of drawings and blueprints, remember that a series of short uniform dashes always represents an invisible surface. Examine figure 4-5 and locate the lines that indicate invisible surfaces (arrow G). See if you understand why they are not visible surfaces; then compare them with the other lines.

Center lines. For the sake of accuracy in the construction of many objects, it is essential to lay off the dimensions from the center of the object rather than from a face or a side. This is particularly true of circular objects or objects made up of circular curved parts. For this reason,the central axis of such objects or parts must be shown in a drawing. The line used to indicate the central axis of an object is known as a *center line.* It is a lightweight line made up of a dash approximately ½ inch in length followed by a short dash approximately ⅛ to 1/16 inch in length. Center lines are of about the same weight as invisible lines. Study the center lines shown in figure 4-4. Figure 4-5 (arrow D) depicts how center lines are used on a drawing.

Dimension lines. If a drawing is to be satisfactory, it must indicate not only the correct shape but also the size of the object and all of its features. The dimensions

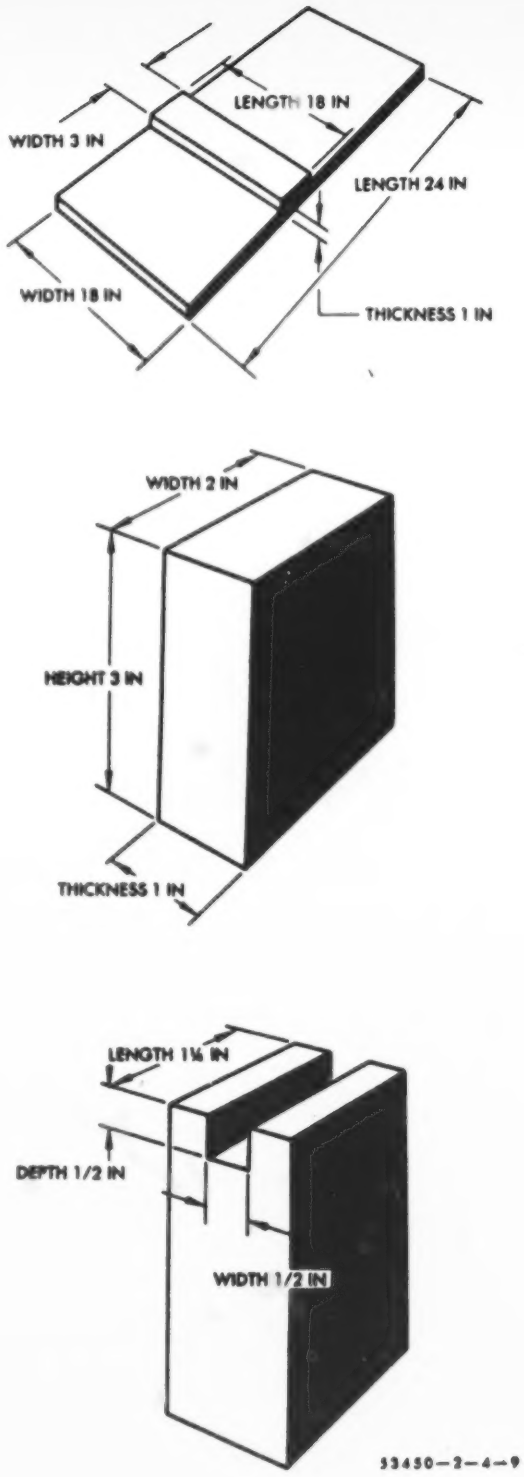

Figure 4-3. Use of descriptive terms.

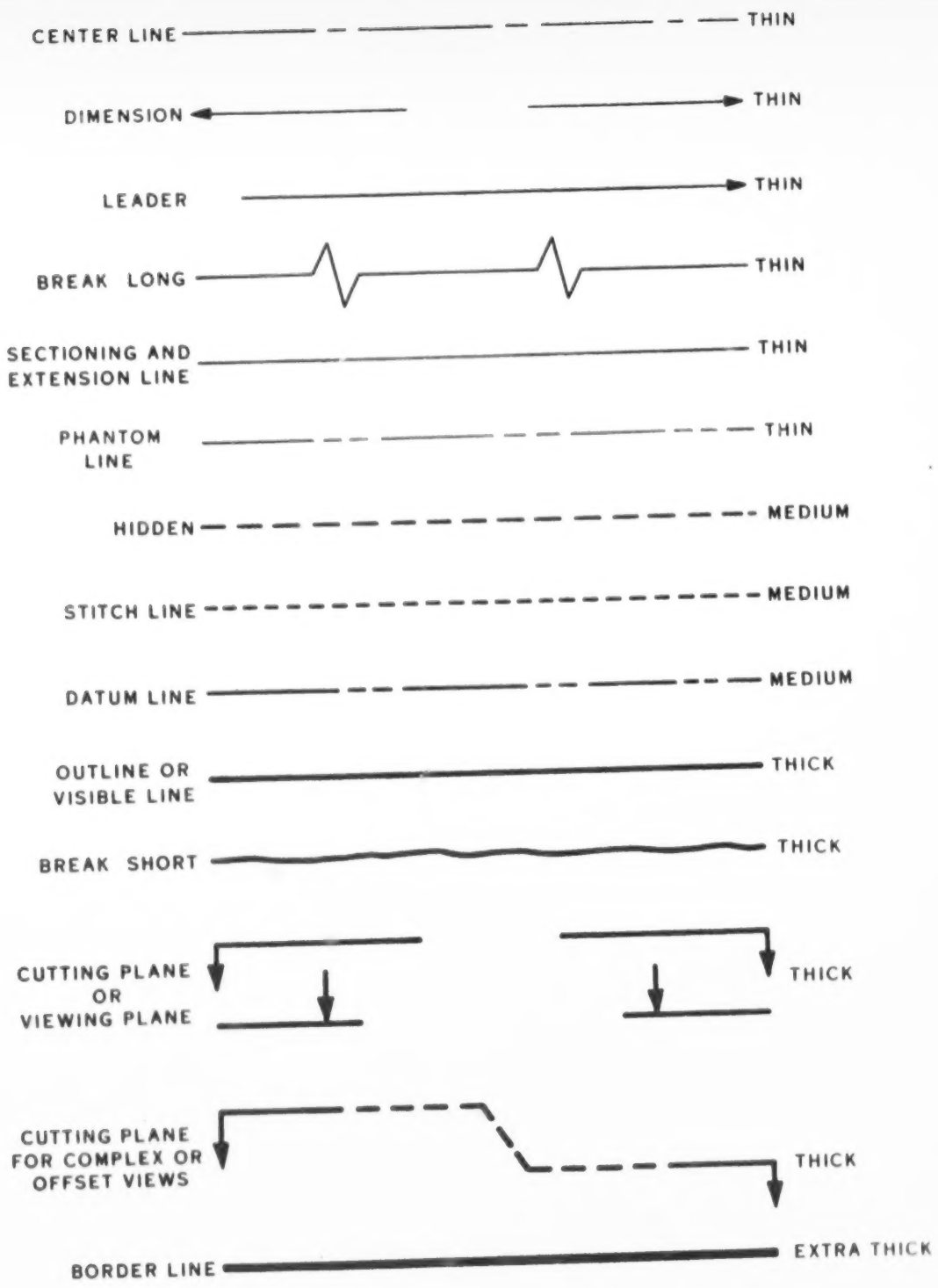

Figure 4-4. Types of drawing lines.

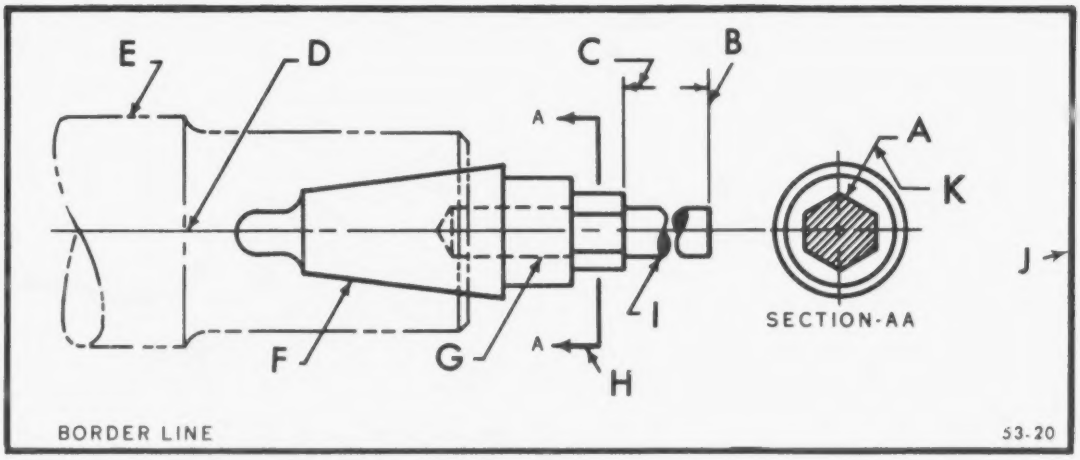

Figure 4-5. Uses of various drawing lines.

of various features are indicated by lines known as dimension lines. These lines may be recognized by the arrowheads on their ends. Dimension lines are solid lines that are lighter than visible outlines. (See fig. 4-4.) Actually, a dimension line is made up of two parts, because it is not a continuous line. It has a space near the center for inserting the size of the dimension. Each half of the line has an arrowhead that indicates the limit of the dimension. (An example of the dimension line is illustrated at arrow C in fig. 4-5).

Extension lines. Usually, the draftsman tries to place all dimensions of an object outside of its outline, primarily for neatness and clarity. However, this is not always possible, as many objects have features on more than one surface, making it necessary to place dimensions within the outline. Whether dimensions are placed within or outside the outline of the surface, the limits of the dimensions must be extended out and away from the feature whose dimension is being shown; otherwise the dimension lines become confusing.

Lines used to extend the limits of a dimension out and away from the feature itself are called extension lines. Such lines begin a very short distance from the object, and are solid and lighter in weight than a visible outline line. (See fig. 4-4.) Usually extension lines are short, particularly when only one dimension is given; but when several dimensions are shown, the lines must be longer. Observe the extension lines shown at arrow B in figure 4-5.

Broken material lines. It is sometimes necessary to indicate on a drawing that a part is broken out or was removed. This is usually done for one of two reasons. It may be to show more clearly the part or parts which lie directly below the part broken out, or it may be to reduce the size of the drawing of a long part so that it may be shown on a smaller drawing. In the latter case, the part broken out is understood to be exactly the same shape as that shown on both sides of the break. When a part is broken out or removed, the break is indicated by irregular solid lines of the same weight as the visible outline lines. These are known as *broken material lines.* One is shown at arrow I in figure 4-5, and one is shown in figure 4-6.

Cutting plane lines. In a drawing which describes an object of unusual shape, it may be necessary to show the exact shape at a particular point on the object. This point is indicated on a drawing by a cutting plane line, which shows that the object has been cut entirely across at that particular point. When such a line is used, a separate drawing representing the cut surface is shown, usually upon the same sheet of paper.

The cutting plane line is made up of a line somewhat heavier than visible lines. It has a short arrow-tipped line on each end at right angles to the cutting plane line. The arrowheads point in the direction from which the cut surface is viewed. These lines are labeled with a letter at each end to identify the drawing of the cut surface which is shown with the same letters and is called a *section.* The cutting plane line and the separate drawing of that surface (labeled section A-A) are shown in figure 4-6.

Crosshatch lines. In drawings it is necessary to indicate that two separate parts meet at a given point. If no distinction were made, a person reading the drawing might assume those parts to be the same piece of material. To distinguish between them, each part is lined or hatched in an opposite direction. Such lines are called hatching or crosshatch lines. They are lightweight solid lines of the same weight as invisible lines. They are placed approximately 1/16 inch apart and are always parallel. (An example is given at arrow A in fig. 4-5.) Remember that when two adjacent parts are crosshatched, the lines always run in different directions. Crosshatching is also used in views like section A-A of figure 4-6 to indicate where a cutting plane intersects parts of an object.

Leader lines. Leader lines indicate a part or areas to which a number, note, or other reference applies,

and they usually terminate in an arrowhead, as does arrow K in figure 4-5.

Phantom. Phantom lines are used to indicate the alternate position of parts of an object, repeated detail, or the location of absent parts, as in figure 4-5. They are made by alternating one long and two evenly spaced short dashes with a long dash at each end.

Sectioning. Sectioning lines indicate the exposed surfaces of an object in a sectional view, as in figure 4-5. They are usually full, thin lines but may vary with the type of material shown.

Border. Border lines are extra heavy lines used to frame or enclose the entire drawing and give the drawing a finished appearance, as at arrow J in figure 4-5.

Break. When an object is uniform in shape, such as a pipe or shaft, and its length prevents it being shown completely on a drawing, a portion is often removed from its midsection, as at arrow I in figure 4-5, thereby enabling both ends of the object to be seen.

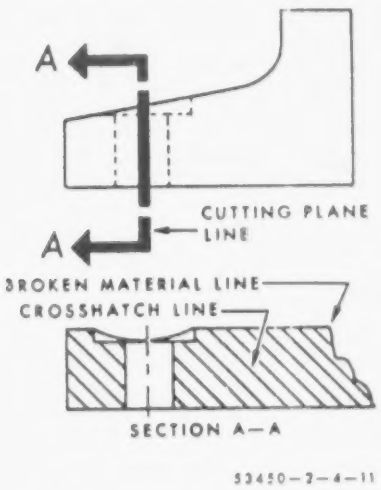

Figure 4-6. Broken material lines.

Exercises (248):

1. Match each line in column A to its best description in column B.

Column A	*Column B*
_____ a. Leader.	1. Alternating long and short dashes with a long dash on each end.
_____ b. Center.	2. Used for framing.
_____ c. Border.	3. Short evenly spaced dashes.
_____ d. Hidden.	4. Indicates part of the object to which some reference note applies.
_____ e. Extension.	5. Light straight lines ending about one-sixteenth of an inch from the object.

2. Which type of line is the basis for comparison of the weights of all other lines?

3. A series of short uniform dashes represents what type of line?

4. How do extension lines differ from dimension lines?

5. What is the purpose of crosshatch lines?

249. List the three general groups of dimensions and describe how different objects are dimensioned.

To manufacture an object, the maker must know the size (or dimensions) of the object and all of its parts. To understand and use a drawing, you must be able to interpret the dimensions on a drawing correctly. Otherwise, the drawing will show you only the shape of the object. Understanding the various types of dimensions and the methods used to represent them is essential in interpreting drawings.

Dimension Groups. There are three general groups of dimensions—overall, position, and detail—as shown in figure 4-7: Draftsmen regularly follow certain standard practices in dimensioning a drawing.

a. Detail or size dimensions give diameters, widths, and measures of other parts of the object.

b. Dimensions are not placed directly on the object.

c. Dimensions that can be shown in more than one view are placed on the view that most clearly illustrates the feature being dimensioned.

d. Hidden edges are not used for dimensioning.

e. All needed dimensions are given, but without unnecessary duplication.

f. Small dimensions are placed near the object, and increasingly larger ones farther away.

g. The symbol or abbreviation for *inches* is omitted. The measurements are understood to be inches unless otherwise stated.

h. Numerals and letters are positioned so that they are read from the bottom of the drawing.

Location of Dimensioning Lines. Draftsmen do not always follow it, but there is a standard procedure for placing dimensions on a drawing. Learn this procedure so you can read drawings and blueprints quickly and accurately.

Angles. Angles are dimensioned as shown in figure 4-8. An arc is drawn and the dimension (degree of the arc) is placed so as to read from a horizontal position. If the angle is too acute to allow space for the dimension inside the angle, it may be placed as in the example of the 10° angle.

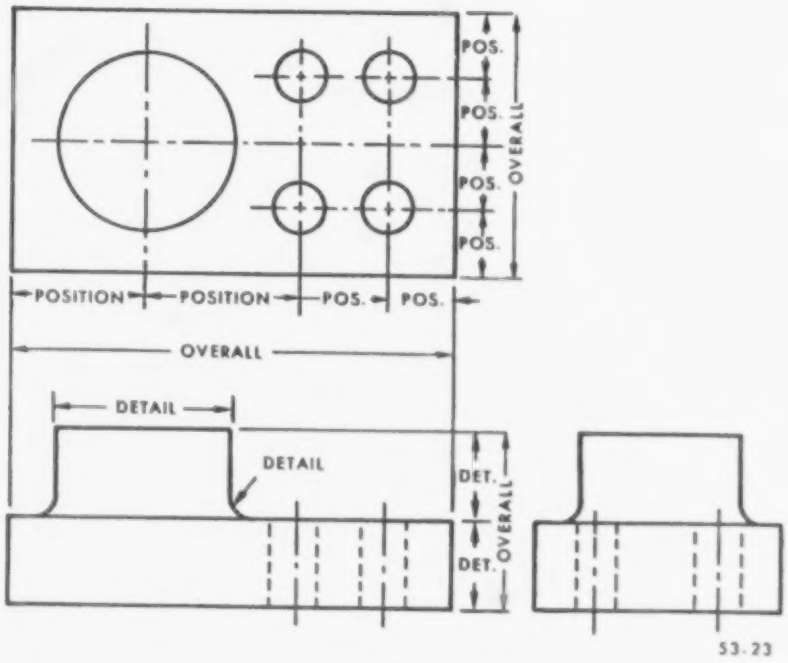

Figure 4-7. Types of dimensions.

Small parts. In the dimensioning of small parts, the available space is often so limited that it prohibits the use of normal size dimensioning lines, symbols, or figures. In such instances, dimensions can be notes or sizes placed to one side with extended arrows, called leaders, to the small parts. (Study fig. 4-9.) Arrows and figures should always be kept in the clear as much as possible.

Tapers. A dimensioning method for an object having inclined or tapered sides is shown in figure 4-10. Outside dimensions are placed farthest from the object, and inside dimensions are nearest to it. "Taper to the foot" means the difference in diameter in 1-foot increments in the length of the object.

Curves. A curved object may be drawn and dimensioned by using several radii, or by what is known as the offset method. In the offset method, the path of the curve is found by taking a number of measurements from an established line, as AB in figure 4-11. Dimensions are marked at points indicated by C and at equally spaced points on the object. The distance between the vertical dimensions is given horizontally, as at point D and at similar points.

Geometric solids. In dimensioning spheres, the diameter is given on the view that is most convenient. Ordinarily, only one view of a cone is needed for indicating the diameter and height. The height of a pyramid can be shown on the front view and any other dimensions on a view of the base. The two necessary dimensions of a cylinder, length and diameter, can be shown on one view.

Circles. Diameter dimensions are given for circles, while radius dimensions are given for arcs. Center lines must not be used as dimension lines; therefore, diameters of circles are sometimes shown by lines within the circle. While this method is approved, a preferred practice is to use extension lines and to place the dimensioning outside the circle. (Fig. 4-12 illustrates both procedures.) Another way, useful on small diameters, is to show the diameter at a leader at one side with the arrow touching the circumference.

Holes. Distances between holes in an object are usually given as dimensions from center to center rather than from outside to outside of the holes. When a number of holes of various sizes are shown, the desired diameters are given on a leader followed by notes indicating the machining operations for each hole. If a part is to have three holes of equal size,

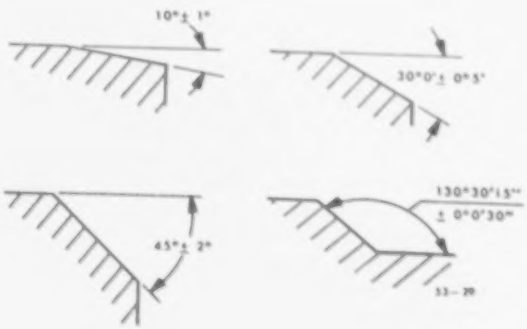

Figure 4-8. Dimensioning angles.

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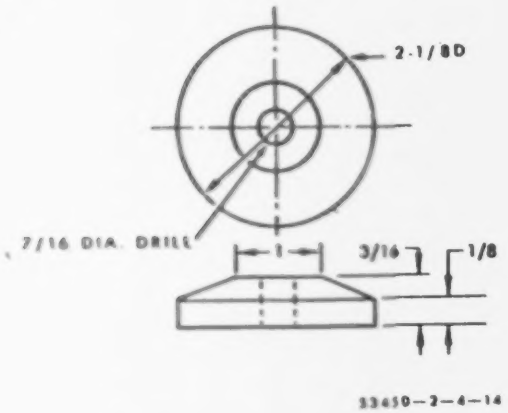


Figure 4-9. Dimensioning small parts.

equally spaced, this information is given. For precision work, sizes are given in decimals. Diameters and depths are given for counterbore holes. For countersunk holes the angle of countersinking and the diameters are given. Study the examples shown in figure 4-13.

Bend radii. A radius is dimensioned by drawing a radial dimension line through the origin of the radius. On a small radius, however, the dimension line may be drawn on the side opposite the center. The letter R always follows the dimensions of the radius. Figure 4-14 illustrates the methods used.

Exercises (249):

1. What are the three general groups of dimensions?

2. To show the center of a hole in relation to edge of an object, you would use (a/an) _____ dimension.

3. To show the diameter of a circular part of an object, you would use (a/an) _____ dimension.

4. To show the entire length of an object, you would give (a/an) _____ dimension.

5. How are the numbers positioned in a vertical dimension?

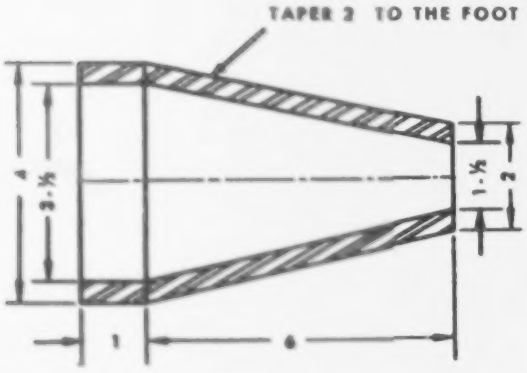


Figure 4-10. Dimensioning tapers.

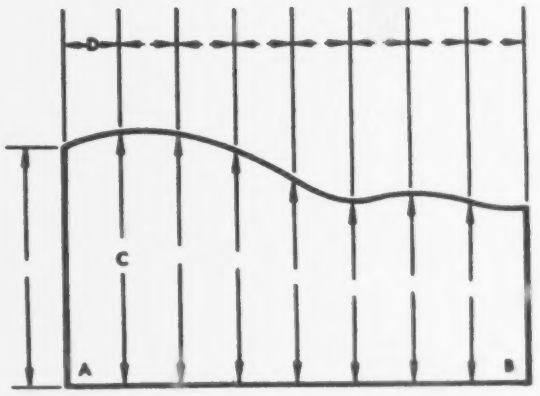


Figure 4-11. Dimensioning curves.

250. Name the type of drawing that fits a given description or characteristic.

Envelope Drawings. Envelope drawings are Air Force drawings that give overall dimensions and mounting instructions. They include any dimensions needed to insure that all articles made from these drawings will be interchangeable, regardless of the manufacturer. All other features are left up to the manufacturer's engineers.

Design Control Drawings. Air Force design control drawings control certain features relating to the design of an aircraft or other equipment. A drawing showing the size of the pilot's cockpit is a drawing of this type.

Installation Drawing. Installation drawings are Air Force or factory drawings showing the manner and location of the attachment of parts to an aircraft or other equipment. An installation drawing (as shown in fig. 4-15,C) includes all necessary information for installing a part or an assembly in its final position in the aircraft. It shows the dimensions necessary for the

location of specific parts with relation to the other parts, and reference dimensions which are helpful for later work in the shop.

Assembly Drawing. An assembly drawing is a description of an object made up of two or more parts. Examine the assembly drawing in figure 4-15,B. It describes the object's size and shape. Its primary purpose is to show the relationship of the various parts. An assembly drawing is usually more complex than a detail drawing, and is often accompanied by detail drawings of various parts.

Subassembly Drawings. Subassembly drawings show two or more parts put together by the shop assembly procedure to form part of a unit of equipment but not a complete assembly.

Detail Drawings. A detail drawing shows only an individual part of an article. It contains all the necessary information needed to manufacture the part. Detail drawings are usually rather simple; and, when single parts are small, several detail drawings can be shown on the same sheet or blueprint. Figure 4-15,A, shows a detail drawing.

Production or Manufacturing Drawings. Production or manufacturing drawings show individual parts of equipment and the assembling procedures for two or more working parts or subassemblies. Production drawings of aircraft, engines, and accessories are principally factory drawings. Usually, the drawings of parts of assemblies pertaining to a particular aircraft are products of factory engineers. Air Force engineers are concerned chiefly with envelope drawings, design control drawings, modifications, and safety devices, and drawings of parts and assemblies that have a more general use. Drawings of condensers, circuit breakers, and solenoids are representative drawings of this type.

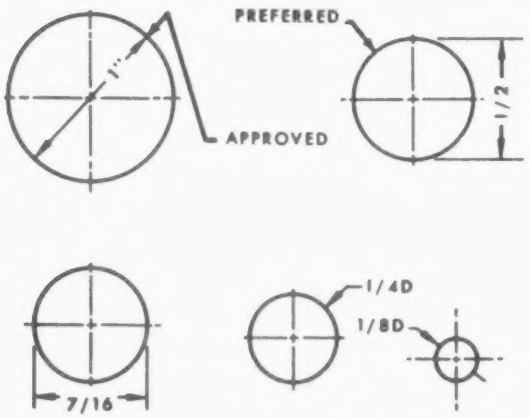


Figure 4-12. Dimensioning circles.

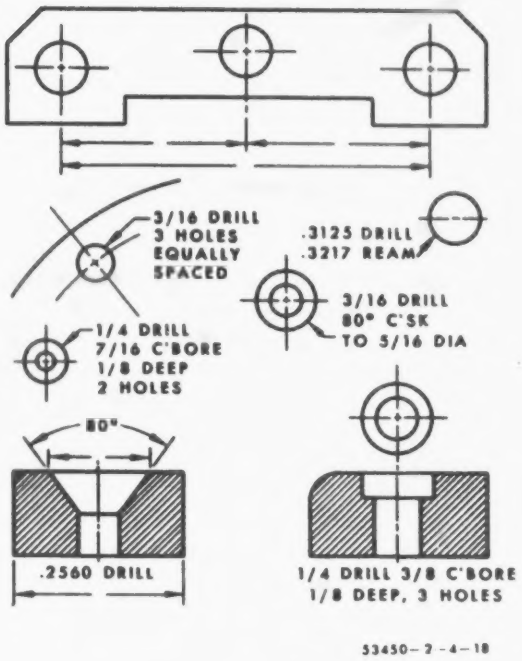


Figure 4-13. Dimensioning holes.

Technical Order Drawings. Technical order drawings and diagrams are often used in performing maintenance and repair. These drawings show assembling procedures, installation of equipment, special modifications, diagrams of the various systems, and methods of repair for all types of Air Force equipment.

Exploded views are used in technical order drawings. The illustration of a stringer repair in figure 4-16 is an example of an exploded view. Notice how the parts are spread out to clearly show each part's relation to the other.

Sectional Drawings. Information concerning interior construction is shown on sectional drawings. A sectional drawing is based upon the assumption that the object has been partially cut or broken away, and the part in front of the break has been removed, thus exposing a view of the interior construction at that point. The surface that marks the intersection of the object with the cutting plane is shaded by a series of crosshatch lines. Figure 4-17 shows the various types of sectional views used on sectional drawings. Note that, when a sectional cutting plane passes through an opening in the solid object, such as a drilled hole for a nut, bolt, shaft, rivet or similar part, the area marking the opening in solid part is not crosshatched.

Exercises (250):
In the space provided in front of each item, write in the type of drawing on which you'll find the item description.

_____ 1. Shows how a repair should be made.

_____ 2. Gives overall dimensions.

_____ 3. Shows where a part is attached to an aircraft.

_____ 4. Shows only one part of an article.

_____ 5. Shows a special Air Force design feature.

_____ 6. Shows assembling procedures for two parts of an engine.

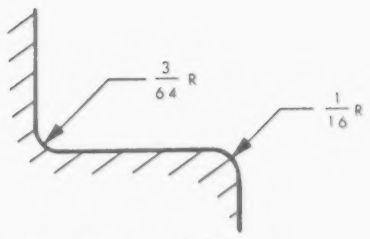
_____ 7. Shows relationship of various parts.

_____ 8. Shows interior construction.

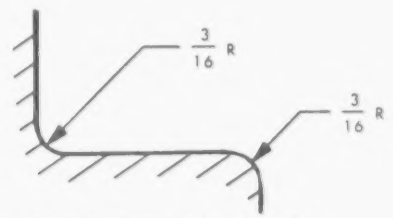
_____ 9. Exploded views are used.

251. Explain significant details of information which appears on a blueprint (AF Form 1654) in addition to the basic drawing.

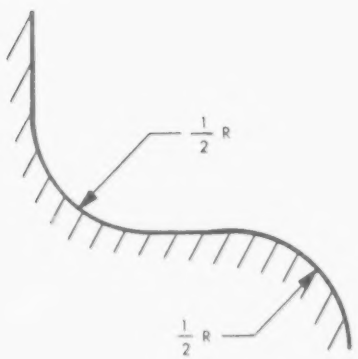
The presentation of an object by the lines of a drawing furnishes the person who is to make it with definite instructions concerning its size and shape. However, it does [illegible]ve him other necessary information he must have if he is to construct the object as it was designed. This additional information—such as name, numer, material from which it



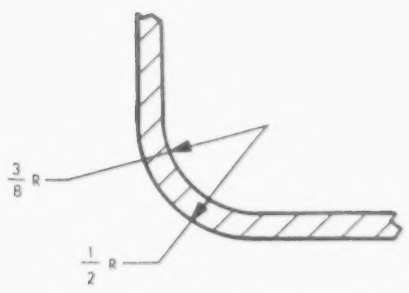
FOR RADII UP TO 3/16



FOR RADII FROM 3/16 TO 1/2



FOR RADII 1/2 AND LARGER



FOR RADII CLOSE TOGETHER

53-28

Figure 4-14. Dimensioning arcs and radii.

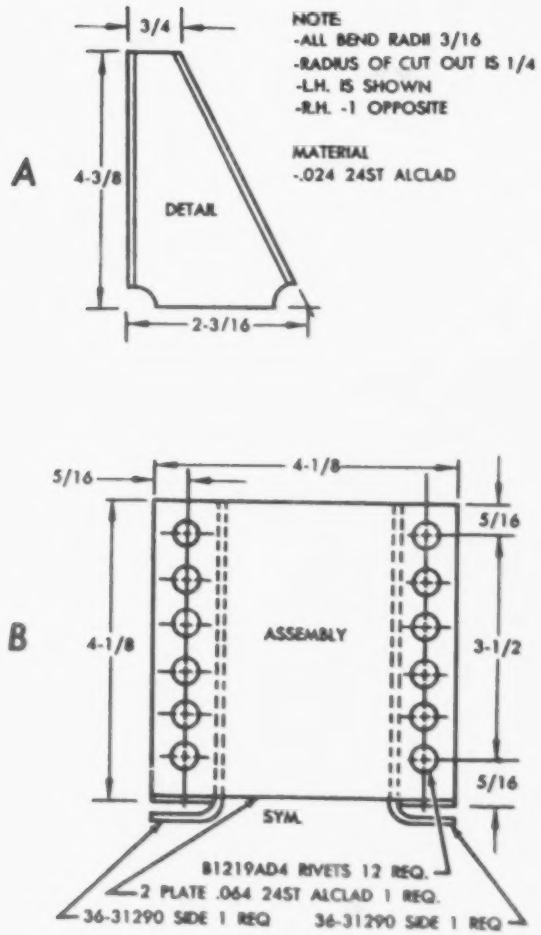


Figure 4-15. Types of blueprint drawings.

is to be fabricated, and other pertinent information—is esential if the object is to be made correctly.

The draftsman must provide this essential information without adding to the complexity of the drawing; yet, it must be placed so that it will be interpreted correctly. Usually, such information is placed in the title block, the change block, or in notes placed so as not to interfere with the drawing itself. In turn, you must be able to read and interpret drawings, prints, or sketches, and sometimes must construct drawings before fabrication or repair. You will seldom use original drawings; you will probably use black and white copies or blueprints.

Title Block Format. Printed and bound in the back of this volume is foldout 1, which is a reproduction of an AF Form 1654. Study it closely as you read the remainder of this information about prints. A blueprint is an economical reproduction of an original scale or working drawing.

Headline. The headlines on the blueprint are in the title block, or box, which is located in the lower right-hand corner of all drawings prepared according to military standards. The title block may appear elsewhere on other blueprints, but the lower right-hand corner is the usual placement.

The title block contains the drawing number and all the information required to identify the part or the assembly that the blueprint represents. In approved military blueprints, the title block of the drawing includes the name and address of the Government agency that prepared it, title, scale, drafting record, authentication, and date.

The portion of the title block which gives the name of the agency issuing the blueprint and the name and number of the part or assembly is located in the lower right-hand corner of the title block. These items are usually in larger and more prominent letters and figures.

Next assembly information. In the left part of the title block there are spaces for the signature of the draftsman, checker, engineer, and the project engineer. Below this there is a space for the contract number and the signature of the authenticating official. Left of this, there is a column for tolerances, material, and the type of finishing required. At the extreme left there are vertical columns in which the application and quantity requirements are normally shown.

Drawing numbers. All drawings are identified by a drawing number which appears in a number block in the lower right-hand corner of the title block. It may be shown in other places—such as near the top border line, in the upper right-hand corner, or on the reverse side of the drawing at both ends—so that the number will show when the drawing is folded or rolled. The purpose of the drawing number is for quick identification of a blueprint. If a blueprint has more than one sheet and each sheet has the same number, this information is included in the number block indicating the sheet number and number of sheets in the series.

Reference and dash numbers. If reference numbers appear in the title block, they refer to the numbers of

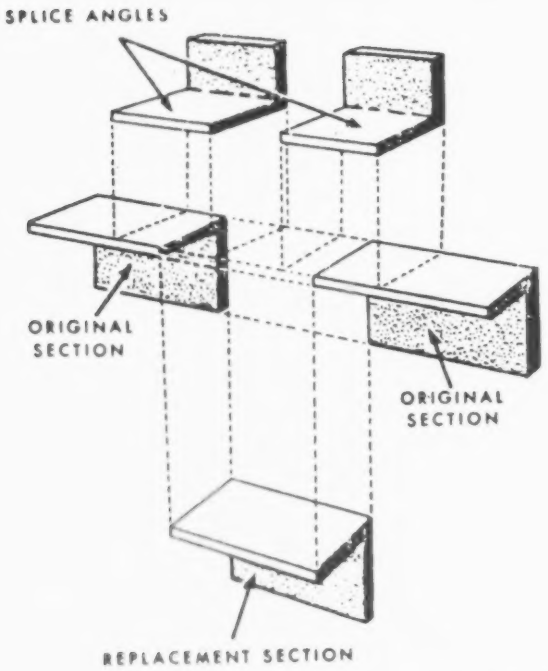


Figure 4-16. Technical order drawing-exploded view.

other blueprints. No reference numbers are shown in foldout 1. When more than one detail is shown on a drawing, dash numbers are used. Let us suppose that two parts are shown in one detail drawing. Both would have the same drawing number plus an individual number, such as 40267–1 and 40267–2.

Dash numbers may be shown in the title block or on the face of the drawing near the parts they identify. Dash numbers are also used to identify right- and left-hand parts.

In aircraft, many parts on the left side are like the corresponding parts on the right side, but in reverse. The left-hand part is always shown in the drawing. The right-hand part is called for in the title block. Above the title block, you may find a notation such as "74204–1LH shown; 74204–2RH opposite". Both parts carry the same number, but the part called for is distinguished by a dash number. Some commercial prints have odd numbers for left-hand parts and even numbers for right-hand parts.

Scale. The scale of the drawing is indicated in one space of the title block. It indicates the size of the drawing as compared with the actual size of the part. The scale is usually shown as 1 inch = 2 inches, 1 inch = 12 inches, etc. It may be indicated as full size, one-half size, one-fourth size, and so forth. If the draftsman has used a scale of 1 inch = 2 inches, the object is shown half as large as its actual size. For a scale of 3 inches = 1 inch, the object is drawn three times its actual size. Very small parts are expanded in size to show views clearly. *Remember:* Never measure a drawing. Use the dimensions given on the blueprint.

Heat-treatment. Most metals require some form of heat-treatment in a manufacturing process. The title block on a blueprint, drawing, or specification lists the type of heat-treatment needed. Frequently, you must remove the temper from a piece of metal so that it can be machined to specifications, after which you harden it. Reference is usually made to the heat-treatment specification in the title block.

Bill of materials and specifications. A special box on the drawing may contain a list of the pieces of stock necessary to make a part or an assembly of several parts. It is called a bill of materials and tells the kind of stock, the size, and the specifications.

Many items (such as bolts, screws, turnbuckles, and rivets) have been standardized by the Army, Navy, and Air Force. Each such item has a number with an AN in front of it. A certain wing nut, for example, has a specification of AN 350. A flathead sheetmetal screw is listed as An 531.

Always use the material specified. The material indicated was selected by an engineer because it meets the requirements of the job it is to do. It is the best material for that particular job. Only an engineer or a person having the authority of an engineer can authorize substitutions of materials when the specified material is not available.

Zones. Zone numbers and letters on blueprints are similar to the numbers and letters printed on the borders of a map. They are there to help you locate a particular point. To find a point, mentally draw horizontal and vertical lines from the letters and numbers specified; the point where these lines intersect is the area sought.

Use the same method to locate parts, sections, and views on large blueprints, particularly assembly drawings. Parts numbered in the title block can be located on the drawings by finding the numbers in squares along the lower border. Zone numbers read from right to left.

Station numbers. A numbering system is used on large assemblies for aircraft to locate stations such as fuselage frames. When you see "Fuselage Frame-Sta 185," you know that the station intended is on the frame 185 inches from nose or intake of the aircraft. The measurement is usually taken from the nose or zero station, but in some instances it may be taken from the firewall.

The same station numbering system is used for wing and stabilizer frames. The measurement is taken from the center line or zero station of the aircraft.

Finish marks. Finish marks are used to indicate the surface that must be machine finished. Such finished surfaces must have a better appearance and allow a closer fit with adjoining parts. During the finishing process, you have to observe the required limits and tolerances. Do not confuse machined finishes with those of paint, enamel, chromium plating, and similar coating. A modified V symbol is used with a number or

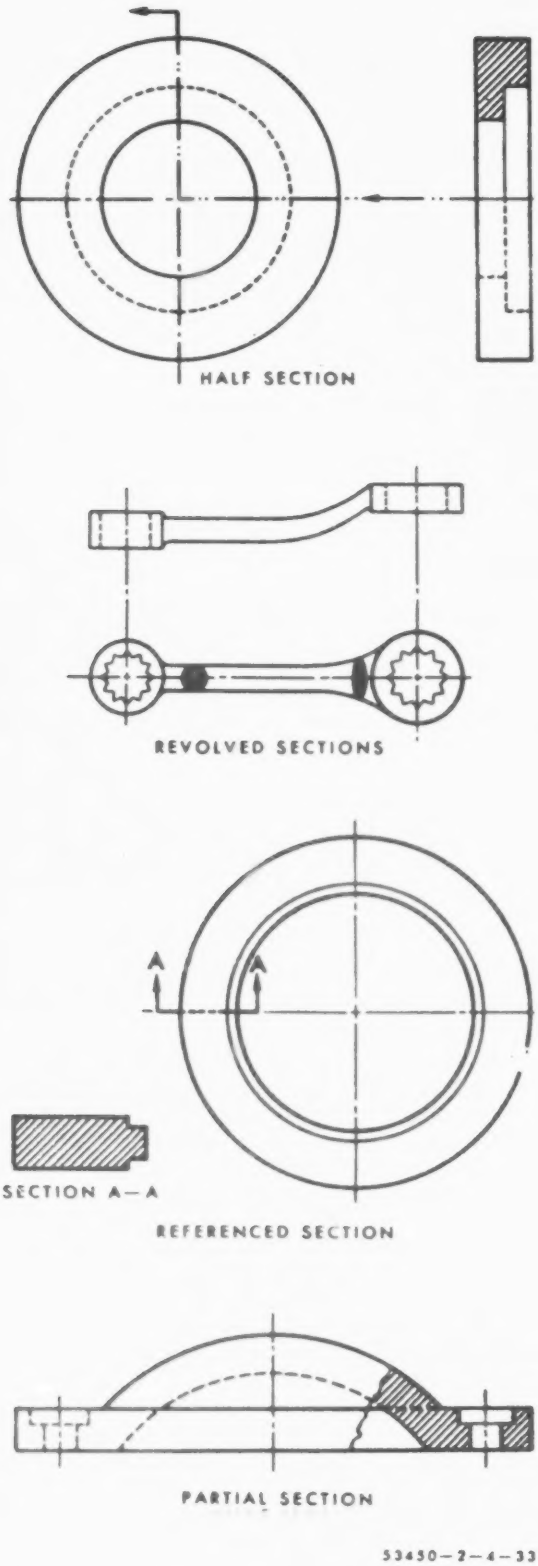


Figure 4-17. Sectional views.

numbers above it to indicate surface finish. (See figure 4-18.)

Drawings prepared according to Government specifications require a surface roughness symbol. Full explanation for the use of these symbols can be found in the publication, *Military Standard Surface Roughness, Waviness, and Lay.*

Tolerance. Tolerance is the amount of allowable variance from a perfect measurement. It is expressed in decimals, usually in at least three places. There are several ways of indicating tolerance on a drawing. With the unilateral method, the minimum or maximum measurement is used as the dimension figure; the allowable difference is given as a plus tolerance figure for minimums or a minus tolerance figure for maximums, as in example A in figure 4-19. In the bilateral method (in example B), the dimension figure indicates the plus or minus variation acceptable. In the limit dimensioning method (example C), the maximum and minimum measurements are both given. These are all accepted methods of indicating tolerance on drawings and blueprints.

When a given dimension on a blueprint shows an allowable variation, the plus figure indicates the maximum and the minus figure indicates the minimum allowable variation. The sum of the plus and minus allowance figures is called *tolerance.* For example, using .225 + .0025 - .005, the plus and minus figures indicate the part is acceptable if it is not more than .0025 larger than the .225 given dimension, or not more than .0005 smaller than the .225 dimension. Tolerance in this example is .0030 (.0025 max plus .0005 min).

If the plus and minus allowances are the same, you will find them presented as .224 ± .0025. The tolerance will then be .0050. Allowance can be indicated in either fractional or decimal form. When accurate dimensions are necessary, decimal allowances are used. Fractional allowances are sufficient when close dimensions are not required. Standard tolerances of -.010 or -$\frac{1}{32}$ may be given in the title block of many blueprints to apply throughout the drawing.

Usage block. A usage block may identify, by drawing numbers, the larger unit of which the detail part or assembly shown forms a component part. This block is usually near the title block; or it may form a part of the list of the material block.

Notes. There are times when you need additional information that cannot be placed in either the title or change blocks on the blueprint. In such cases, the information is put on the face of the blueprint in a position which does not interfere with the title block, the change block, or the drawing itself. The information is specific and applies to a particular part or parts.

When the note refers to a specific part, a light line with an arrowhead leads from the note to the part. If it applies to more than one part, the note is worded so that you will make no mistake as to the parts to which it pertains. When there are several notes, they are generally grouped together and numbered consecutively.

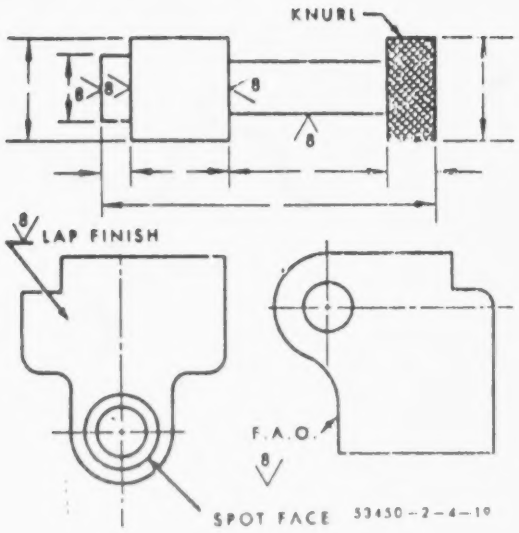


Figure 4-18. Dimensioning finishes.

Change or revision block. A revision block is located on the right-hand side of the print. The general practice is to put this block in the upper right-hand corner, but it may be placed above the title if desired. All changes to the drawings are entered in this block, and dated and identified by a number or a letter. If a revision block is not used, a revised drawing may be shown by adding a letter to the original number (for example, 140365-21-A).

Thread depiction. There are various ways of representing threads on a blueprint. Figure 4-20 indicates how outside threads are shown. At top left you can see a thread profile in section. On the right is an ordinary method of showing threads. To save time, a draftsman uses symbols when objects are not drawn to scale. The length of the threaded part is dimensioned, but other necessary information appears in the note, which in this case is ¼-20-NC-2.

The first number, ¼, indicates the nominal size, which is the outside diameter. The number 20 after the first dash indicates there are 20 threads per inch. The letters NC indicate the thread series, National Coarse. (The two most widely used screwthread series are the National Coarse (NC) and National Fine (NF) threads. The NF threads have more threads per inch of screw length than the NC.) The last number, 2 indicates the class of thread and tolerance, commonly called the fit. If it is a left-hand thread, a dash and the letters LH in bold type follow the class of thread. Threads without the LH are right-hand threads.

Internal threads may also be shown by several kinds of symbols. Here, again, it is not necessary to draw the threads when a simple symbol will do just as well. In figure 4-20, holes A and B have the same threads as hole C, as indicated by the note. Notice that the threads in the preceding illustration may be screwed into these threaded holes. How do we know? The note on each one tells us that the threads are exactly the same. Threads may be shown in sections, especially in assembly views. The illustration clearly shows the relationship of the threaded members. Bolts, studs, and capscrews are indicated on drawings by outlines and symbols as shown at the bottom of figure 4-20.

Size and Use. As stated previously, drawings are made full size when possible, or as nearly so as can be suitably approached. In large aircraft companies where thousands of blueprints are used and retained for future reference, some thought must be given to their storage, for uniformity of storage, the prints are made according to a set of standard sizes. Eight and one-half by eleven inches has become the standard size for most small drawings or blueprints. Larger sized drawings are usually made in some multiple of this size, which permits folding to the standard size and storing conveniently.

In learning to read blueprints, remember that drawings or blueprints should never be measured (or scaled, as it is often called). Drawings, when complete, should indicate all dimensions, thus making it unnecessary to measure them. A drawing that is incomplete—does not give specific dimensions—should be returned to the drafting or engineering department to be corrected.

Exercises (251):

1. Where is the title block usually located on a blueprint?

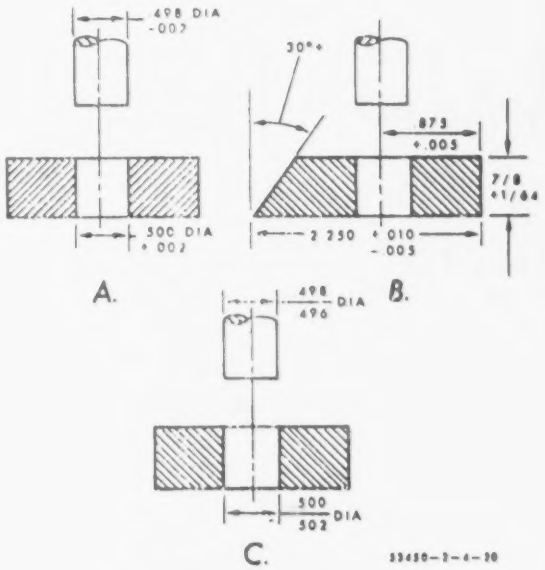


Figure 4-19. Indicating tolerance.

2. What is the purpose of drawing numbers?

3. What side of an aircraft or aircraft part is usually shown on blueprints?

4. What is meant by the term "scale"?

5. Why are zone numbers and letters placed on a blueprint?

6. A modified V symbol with a number above it indicates _____ .

7. Name the methods used to indicate tolerance on a blueprint.

8. Identify each of the individual parts of a screw information number ⅜–15–NC–2.

9. What must you remember when using blueprints?

10. When are dash numbers used on a blueprint?

252. Point out the advantage of placing drawings on microfilm.

Microfilms and Their Uses. The practice of recording drawings on microfilm was introduced in recent years. Microfilm is regular 16mm or 35mm film. Since 35mm film is larger, it provides a better reproduction of drawings.

Recently, a new method of microfilming, called microfiche is being used to store data. Microfiche is a flat sheet of microfilm approximately 4 inches by 6 inches in size. The reason for using this type of data storage is the tremendous amount of information that can be stored on one microfiche.

A volume of a supply *Master Cross Reference List, Part 1,* containing 10 million entries, can be placed on 216 microfiche, a stack measuring only 1-inch high. As

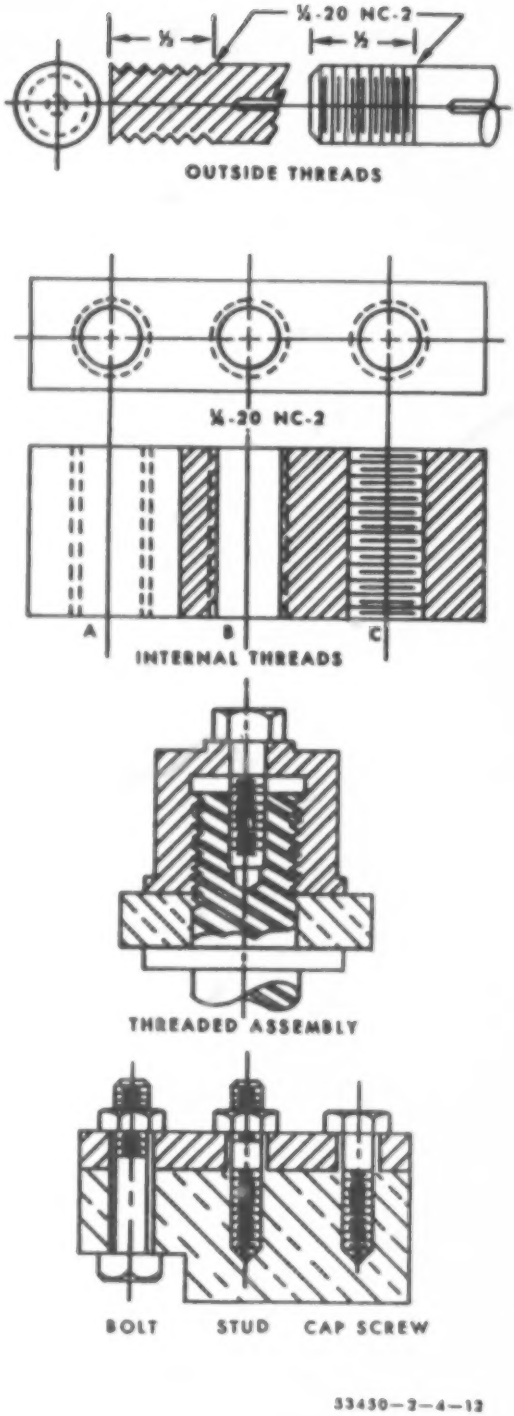


Figure 4-20. How threads are drawn.

for drawings, the necessary number of fiche varies according to the size of the original drawings. A special viewer is required for reading microfiche. If you need to study a particular drawing for a long period of time, an enlarged photographic reproduction can be made, using the microfiche as a negative.

Microfilm and microfiche of drawings have many other uses and advantages. However, they are not intended to replace original drawings, especially where the originals are modified and kept current over long periods of time.

Exercises (252):

1. State one advantage of placing drawings on microfiche.

2. How are microfiche read?

3. If you need to study a drawing on a microfiche for a long period if time, what can you do?

4. Why can't microfiche totally replace original drawings?

4-4. Types of Drawings

Earlier in this chapter, we covered how to interpret drawings and blueprints. This part deals with the types of drawings you can develop to convey your thoughts to others and use for the fabrication of parts. It is very important that you understand the methods used to construct drawings. Most of your work involves some type of drawing—be it a simple shop sketch or detailed mechanical drawing.

253. Explain elementary relationships between the surfaces of an object and drawings of the object.

Surface Drawings. The face of any solid object is called a *surface*, and the limits of any surface on a drawing are indicated by means of lines. A surface has two dimensions, length and width. It does not have thickness. When it is necessary to indicate an edge view of a surface, a line is used. Even though the line has thickness, the surface itself does not.

Number of surfaces. Study the object illustrated in the first of the illustrations on figure 4-21. You can determine that it has six surfaces. These surfaces are usually called the front, back, top, bottom, right side, and left side. Now study the second illustration. We can recognize the same object with a groove cut in the top surface. If we count its surfaces, we can determine that there are 10. Examine the third illustration. We find the same object, except that a projection is shown on the bottom. Count the surfaces and we find there are 14. It is easy to see from the study of these illustrations that the number of surfaces upon an object can be increased or decreased by changing its shape.

Number of views. In order to show three dimensions, it is usually necessary to show at least two views.

Many times it is desirable to make a drawing of three views of an object. This is necessary when it has special features that cannot be shown in two views with sufficient completeness to enable a repairman to construct the object without additional information. For this reason, projection drawings consisting of three views are used. These views are usually the front, top, and either the right or left side views.

Single-view drawings are used only for objects made of thin material, such as sheet stock, and only when they are perfectly flat, never when they are bent or curved. Look at figure 4-22, which illustrates a one-view drawing of a reinforcement plate. The plate is to

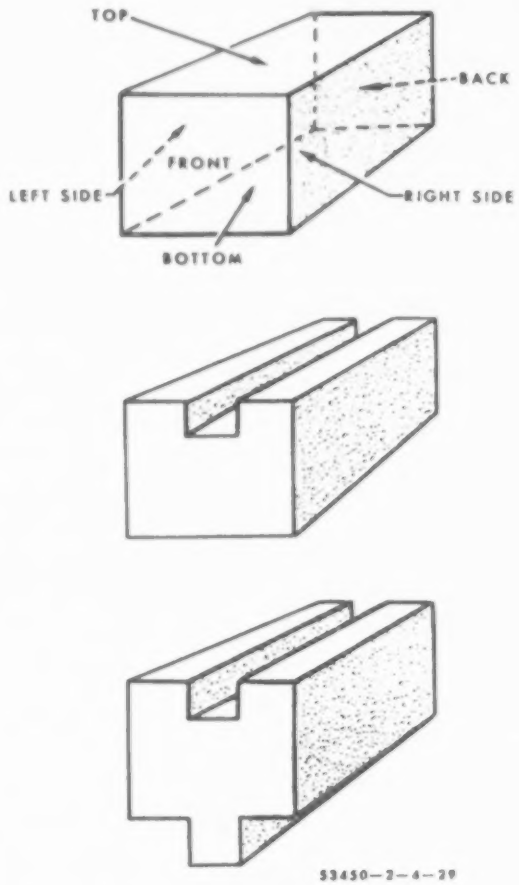


Figure 4-21. Surface drawings.

be made of sheet stock, and other views would only show the thickness of the stock (0.040) in addition to the length and width which are given in the single view shown. To attempt to show this thickness, the lines representing the two faces would be so close together they would appear as one line. Since a note stating the thickness of the material can be made, it is placed on the single-view drawing.

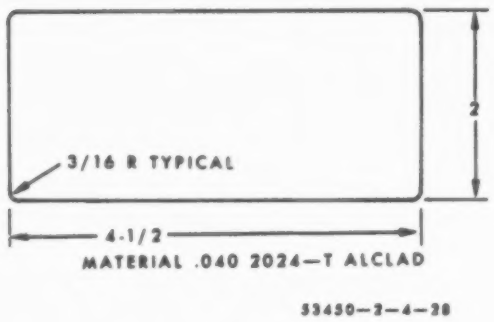


Figure 4-22. Reinforcement plate.

Figure 4-23 illustrates the six surfaces of a plain object by showing a view for each surface. Such a drawing, obviously, requires more time, labor, and a larger piece of paper.

For these reasons, a drawing usually presents the six surfaces by three views. This can be done very satisfactorily by identifying the outline of visible features with solid lines, and of invisible features with dotted lines.

Auxiliary surface view. When an object has an inclined surface, like the object in part A of figure 4-24, the true measurement and appearance of the inclined surface cannot be presented in any of the three standard views of a drawing. An auxiliary view is used to project the inclined surface onto a plane parallel to it. This view presents the surface as it actually appears when viewed from a 90° angle. Part B of figure 4-24 presents the standard views of the front and the right side of the object. The dimensions of all edges and surfaces indicated in part A are accurately drawn in the views in part B, except for those representing the inclined surface. To obtain accurate dimensions, it is necessary to project a view to a plane that is parallel to the inclined surface. Parts C, D, and E show the steps by which the draftsman projects such a view. Since you don't need to know it, we will not explain the procedure (it is not nearly so complicated as it appears to be); but the result is that the shaded portion in section F is an accurately drawn auxiliary view of the inclined surface portion of the right side of the object.

Curved surface views. Curved surfaces do not always look curved in a draftsman's drawing. This is because you are looking at the top, bottom, or side of an object at 90° to the surface—looking directly at it. You often see curved edges which indicate a curved surface behind them; but when you see the surface itself in another view, you see it broadside and it appears flat.

The example illustrated in figure 4-25 is a two-view drawing of a cone. You know that the side of a cone is curved, but you cannot see the curvature in example B. You can see the bottom edge of this curved side in example A, so you know that it does exist. It is a good idea to keep in mind that curves in orthographic drawings do not show curved surfaces but may indicate a curved surface behind them. It is up to you to find that surface on one of the other views.

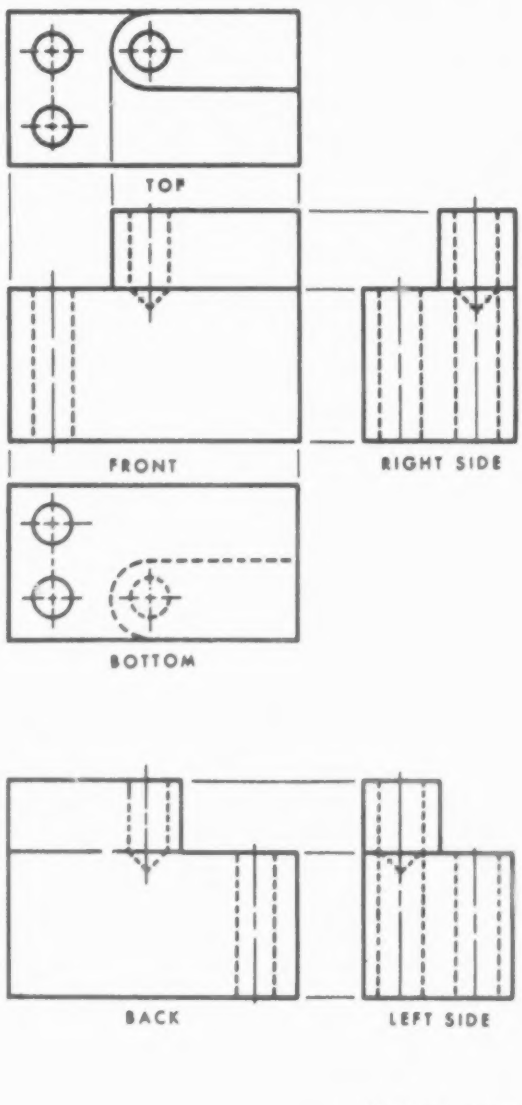


Figure 4-23. How surfaces are shown.

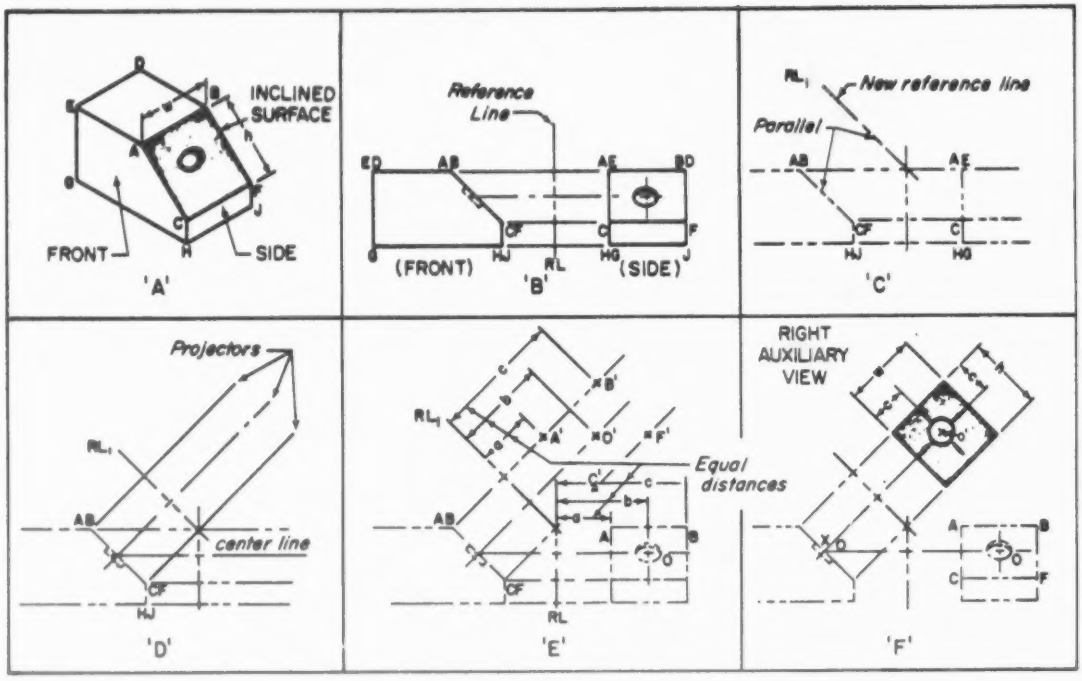


Figure 4-24. Auxiliary surface view.

Exercises (253):

1. How many dimensions does a surface have?

2. What determines the number of surfaces shown on a drawing?

3. How many views of an object are usually shown on a drawing?

4. What type of view is used to show the true measurement and appearance of an inclined surface?

5. Why is it difficult to locate curved surfaces in orthographic drawings?

254. Describe characteristic features of three types of mechanical drawings.

Orthographic Drawings. The best way to draw many objects is to project them on paper in some combination of front, top, and side views. Showing several (usually three) views of an object from viewpoints at 90° to each other is called *orthographic projection.* To understand this three-view type of projection, imagine that the object is resting inside a rectangular-shaped box with transparent plastic sides, as in figure 4-26. Now imagine yourself looking straight down at the top of the object and tracing on the plastic boxtop what you see of the object. The result would be a rectangle such as you see labeled TOP in figure 4-26. Note how

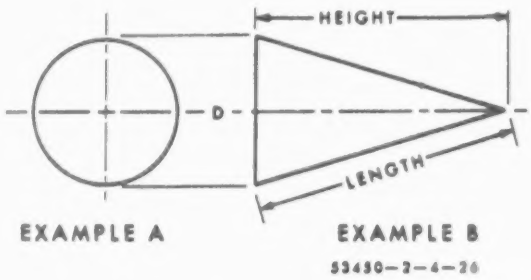


Figure 4-25. Solid cone.

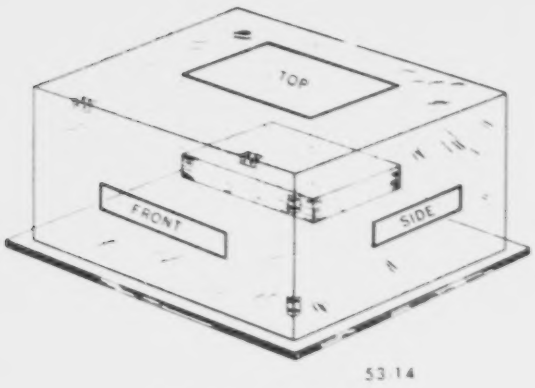


Figure 4-26. Projected views.

the four corners of this rectangular tracing match up with the four corners of the object, as shown by the vertical dashes known as projection lines. Observe how the front- and right-side tracings appear as projections of what you would see if you were looking directly at the object from those particular angles.

To understand view alignment, imagine swinging the hinged sides of the plastic box around, flattening them out into a single plane, as though you were laying them flat on drawing paper. Note in figure 4-27 that the top view aligns directly over the front view, and the side view appears directly to the right of, and in line with, the front view. This is an orthographic projection, showing the exact size and shape of the object. When it is copied on paper with the necessary dimensions added, as in figure 4-28, you have a working drawing. You can work from an orthographic projection much more easily than from a picture of the object as your eye sees it.

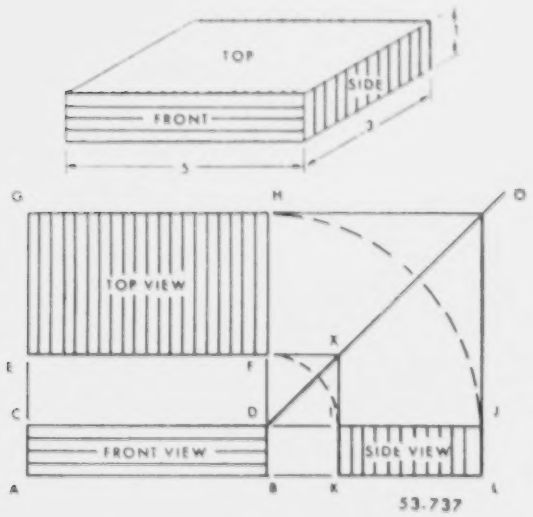


Figure 4-27. Orthographic projection.

To illustrate orthographic projection, we have used a rectangular-shaped object. It would have been possible to project six views of it, but three would have served no purpose since the views of the top and bottom are identical, the front and back are identical, and the right side and left side are identical. The shape of the object determines the number of views that are needed. For example, to present more than one view of a spherical object would just be needless repetition.

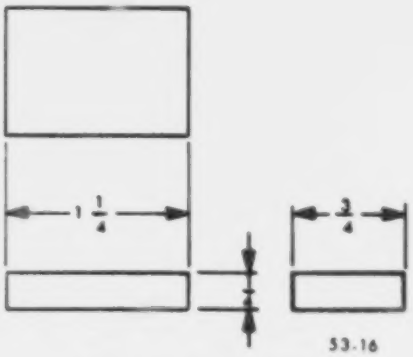


Figure 4-28. Working drawing.

Isometric Drawings. Isometric drawings are often used to help visualize an object and to give depth to a drawing. They combine some dimension accuracy with pictorial representation. For simple objects they are sometimes used alone, but more often they are used in conjunction with orthographic drawings. A drawing of a box with square corners is an example of an isometric drawing. The drawing is built on a skeleton of three lines representing three edges of a cube, such as lines 1, 2, and 3 in part A of figure 4-29. Note that line 1 is vertical and that lines 2 and 3 are drawn from 30° from the horizontal. These lines, called isometric axes, form equal angles of 120°. The true dimensions (length, width, and height) are laid off on the isometric axes, and lines are drawn through these points parallel to each axis to complete the drawing. Any line drawn parallel to an isometric axis is called an *isometric line*. Measurements can be made only on the isometric lines. The angles between isometric lines do not show their true size. For example, the isometric drawing in part B of figure 4-29 represents a square-cornered (90°) box, whereas the angles in the drawing are 120° and 60°.

To construct angles other than 90°, the lines forming these angles must be transferred from the orthographic drawing to the isometric drawing, as shown in figure 4-30. You recognize at once from the three orthographic views in part A that the object is not rectangular. Even so, constructing an isometric drawing of the object is quite simple. Perpendiculars are drawn on the front view from points D and E to points F and G on line AC. The AB and AC isometric axes (in part B) are drawn, points F and G located on line AC, and

vertical lines DF and EG (perpendicular to a horizontal plane as indicated in part A) are drawn. The nonisometric lines AD and CE are drawn, correctly representing the angles at A and C. The drawing is completed by adding the necessary isometric lines, as shown in section C.

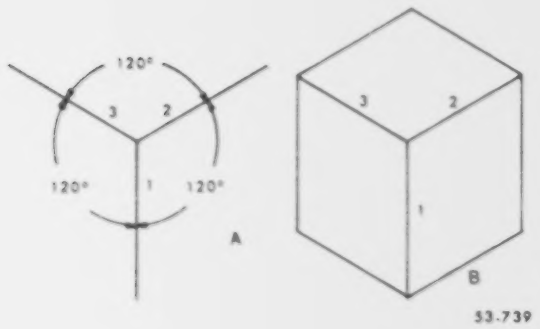


Figure 4-29. Isometric axes.

Oblique Drawings. In an oblique drawing, the object is placed parallel to the plane of projection and projected to this plane by oblique, rather than perpendicular, projection lines. An oblique drawing is also built on a skeleton of three axes; two axes intersect at a right angle, and the third axis is drawn at any convenient angle, as shown in part A of figure 4-31.

The same methods and rules used in isometric drawings apply to oblique drawings. Oblique drawings show the face of the object without distortion. Consequently, objects with irregular outlines can be presented more easily by this method. By changing the projection angle used, more or less of the top or sides of the object can be shown, allowing either section to be stressed by the drawing, as desired. In making an oblique drawing, the draftsman should place the object so that the irregular outline or contour faces the front. If there is no irregular outline, the object should be placed so that the longest dimensions are in front. Figure 4-32 is a typical example of an oblique drawing made from an orthographic projection drawing.

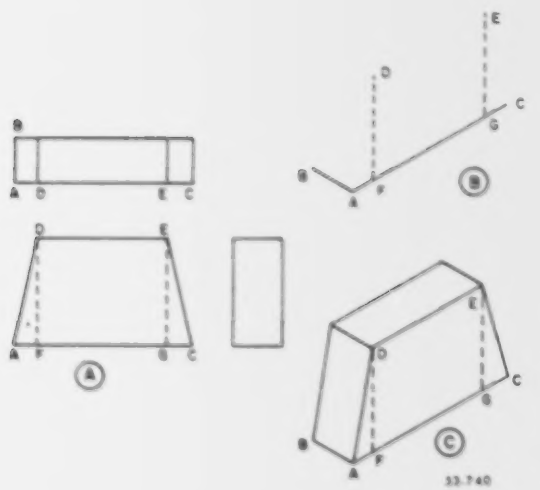


Figure 4-30. Isometric drawing.

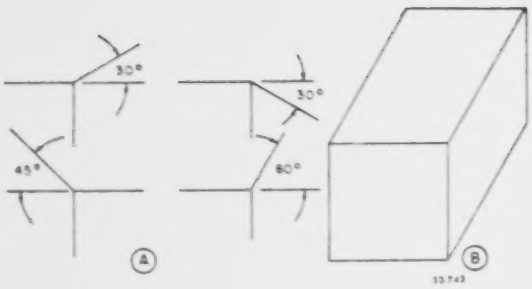


Figure 4-31. Oblique projection lines.

Exercises (254):

1. How many views for a rectangular box does an orthographic projection usually show?

2. What views of a box are shown in an orthographic projection?

3. How do the various views of an orthographic projection align?

4. For what type of objects are isometric drawings alone usually sufficient?

5. What objects are best presented by oblique drawings?

6. How is an object positioned and projected in an oblique drawing?

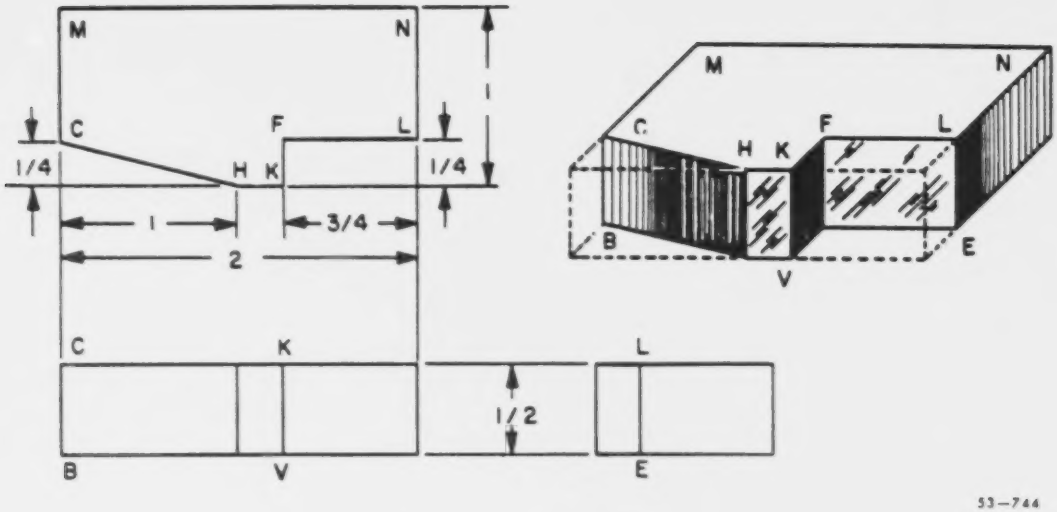


Figure 4-32. Oblique drawing.

4-5. Geometric Construction of Drawings

Problems often arise in layout work and in drafting that can be solved only by the construction of geometric figures, using a pencil (or scribe), a straightedge, and compass (or dividers). Geometric construction involves the construction and division of lines, angles, and arcs, and the construction of regular pentagons, hexagons, and octagons. On occasion the points of reference may be given in such a way that direct measurement or layout is not possible, or the outer edges of the object may be uneven or so shaped that you cannot use them as guides for a square, protractor, or other tool. When this is the case, you must use geometric construction to lay out the object.

255. Define geometric construction and list five common geometric constructions.

Geometric Construction. *Geometric construction* is the construction (drawing), and layout of points, lines, and figures using only a straightedge and a compass. In drafting, geometric construction may not be the only way to solve a problem, but it is the most accurate. For example, you can establish the midpoint of a line with a scale, but you can do it much more accurately by bisecting the line with dividers. We will discuss the basic geometry construction procedures.

Bisecting lines. To bisect a line (divide it into two equal parts) geometrically, use the ends of the line (points A and B in fig. 4-33) as pivot points for the compass and draw arcs with a radius greater than one-half of line AB, so that they intersect on each side of the line. Then draw a line between the points of intersection of the arcs, points C and D. Line CD bisects line AB, and is also perpendicular to it.

Bisecting arcs. To bisect an arc, use the ends of the arc (points A and B in fig. 4-34) as pivot points, and using a radius greater than one-half the distance of AB, draw arcs that intersect at C and D. A line drawn between points C and D then bisects arc AB.

Bisecting angles. Using any desired radius and point A in figure 4-35 as a pivot point, draw arc ED. Using points E and D as pivot points, and a radius greater than half the distance ED, draw arcs that intersect at point 0. A line drawn from point 0 to point A bisects angle CAB.

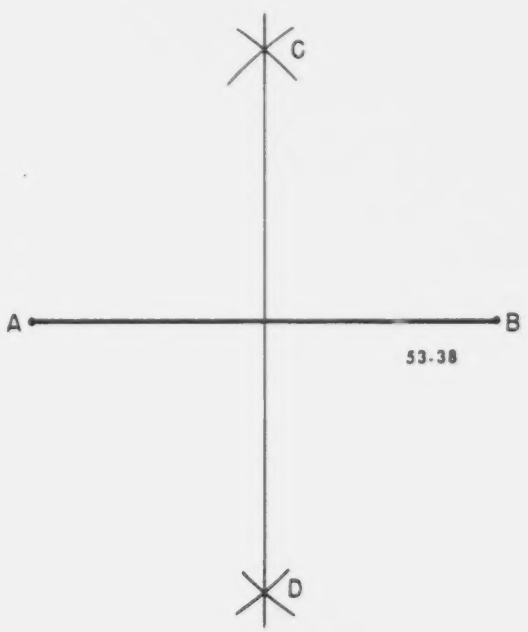


Figure 4-33. Bisecting lines.

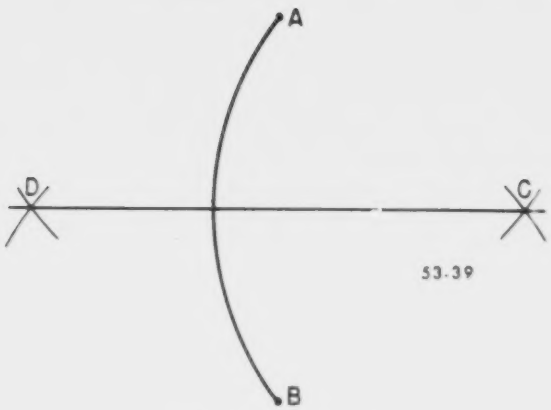


Figure 4-34. Bisecting arcs.

Erecting a perpendicular from a point off a line. Using point P as a center and a radius greater than the distance from P to line AB (fig. 4-36), draw an arc that intersects the line at points C and D. With points C and D as the pivot points and any radius greater than distance CF, draw arcs that intersect at point E. You may use a radius longer than distance PF, as shown on the left, or shorter than PF, as shown on the right. A line drawn from point E through point P and extended to line AB is then perpendicular to line AB.

Erecting a perpendicular from a point on a line. Using point P in figure 4-37 as a pivot point and any desired radius, draw arcs that intersect line AB at points C and D. Using points C and D as pivot points and a radius greater than one-half of distance CD, draw arcs that intersect at point E. A line drawn from point E to point P is perpendicular to line AB.

Dividing a line into equal parts. You can divide a line, such as AB in figure 4-38, into any desired number of equal parts by drawing a line, such as BC, at any angle from point B. With the compass (or dividers) at any convenient setting, step off the desired number of divisions on line BC. (The last division mark on BC does *NOT* have to coincide with point C.) Connect the last division mark to point A. Lines drawn parallel to line AC through each of the division marks on line BC then divide line AB into the desired number of equal divisions.

Constructing lines parallel to a line. Using the desired distance from line AB (fig. 4-39) as a radius and any two points on line AB as pivot points 1 and 2, construct two arcs. (The farther apart points 1 and 2 are, the more accurate the results will be.) Line CD drawn tangent to the arcs is then parallel to line AB.

Constructing arcs tangent to intersecting lines. Using the desired radius, construct lines parallel to intersecting lines AB and BC, as shown in figure 4-40. Using point E as a pivot point, draw the desired arc. It will be tangent to the original lines.

Constructing an arc of a given radius within a right angle. You *could* use the method of the preceding paragraph, but in this case there is an easier way. Using the desired radius, and point A as a pivot point, draw an arc that intersects the sides of the right angle, such as angle CAB in figure 4-41. With the same radius, and using points E and D as the pivot points, draw intersecting arcs that locate point F. Using point F as the pivot point, draw an arc with the desired radius tangent to both sides of the right angle.

Exercises (255):

1. Define geometric construction.

2. List five applications of geometric construction.

4-6. Layout Development.

Layout work is the careful measuring and marking of sheet metal prior to cutting and shaping the metal. Measurements for a layout can be obtained from a blueprint or from the original part to be duplicated. There are three reasons for using a flat layout when fabricating or repairing aircraft component parts:

(1) *Accuracy.* The flat layout insures that the bends and size will duplicate the original part. When aircraft repairs are not exactly made to size, the applied stresses concentrates at the weak points, which will eventually cause failure of the part.

(2) *Duplication.* The flat layout is used when more than one part having the same size and shape is to be made. Identical measurements are easily transferred to the new metal, and duplication is quickly achieved.

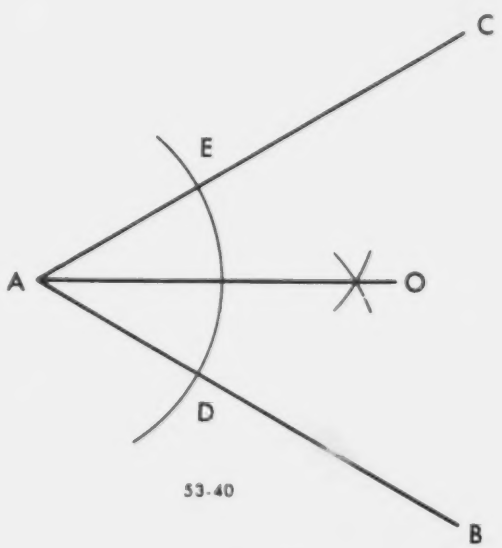


Figure 4-35. Bisecting angles.

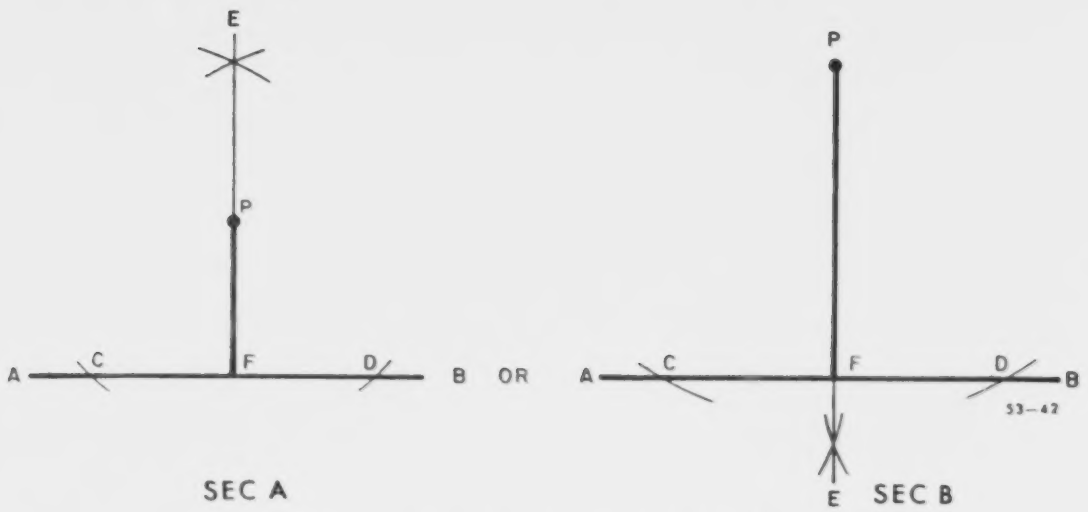


Figure 4-36. Erecting a perpendicular from a point off a line.

(3) *Economy*. The use of flat layout insures that the least amount of metal is used on each job. This method guarantees a minimum of cost for each job.

256. By definition or response to questions using layout terminology, differentiate between the terms used to develop layouts.

Since most of the layouts you will develop will lead to some type of forming operation, we will discuss terms associated with layout and the actual bending together. For a good understanding of a flat metal layout to be bent, you must be familiar with the following terms.

Overall Dimensions. Overall dimensions are the outside dimensions of a complete or formed part. Overall dimensions determine how large a part is to be made. These measurements by themselves do not determine the amount of metal to be used, but only indicate the desired size of the completed part. They are given on drawings and blueprints or can be obtained from the original part.

Overall measurements, sometimes called base measurements, must be accurate because it is from them that the other bending factors are calculated. Flanges are measured from the top of the flange to a reference point called the mold point. Figure 4-42 shows the location of the mold point. The mold point is a reference point for figuring overall dimensions. When the outside surfaces of a formed part are extended, as shown in figure 4-42, they intersect at a point outside the formed part. The mold point is quickly found with the aid of combination square head and rule. Overall dimentions for outside areas of a "U" channel are measured from mold point to mold point.

Bend Allowance. The amount of metal which is required to form the bent section of a part is called bend allowance. The starting and ending points of the bent area are called bend tangent lines. During the bending operation, the material on the inside of the curve compresses and the material on the outside, stretches. The neutral axis is not affected by either of these forces. Consequently, bend allowance is figured along the neutral axis within the metal. Note the location of the bend allowance line in figure 4-42.

Bend allowance depends on four factors: the degree of bend, the radius of the bend, the thickness of the material, and type of material. A change in one directly effects the other three.

Degree of bend. The term *degree of bend* is used to identify the formed position of the material after forming. The degree of the bend or fold can be anything from 1° up to and including 360°. The shape could be an angle or a curve. (Ducting, tubing and piping are examples of a 360° bend.)

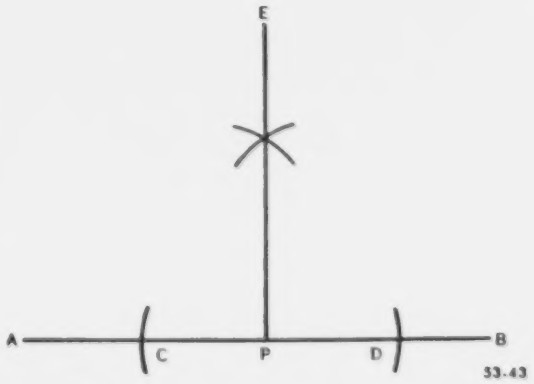


Figure 4-37. Erecting a perpendicular from a point on a line.

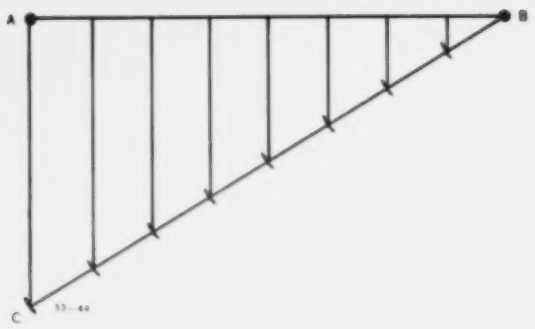


Figure 4-38. Dividing a line into equal parts.

Radius of bend. The radius of bend of a sheet of material is the radius of bend as measured on the inside of the curved material. The minimum radius of a sheet of material is the sharpest curve, or bend, to which the sheet can be bent without critically weakening the portion at the bend. If the radius of bend is too small, stresses and strains weaken the metal and may result in cracking.

A minimum radius of bend is specified for each type of aircraft sheet metal. The kind of material, thickness, and temper condition of the sheet are factors affecting it. You may bend annealed sheet to a radius approximately equal to its thickness. Stainless steel and 2024–T aluminum alloy require a fairly large bend radius.

The radius of the bend is generally proportional to the thickness of the material. Furthermore, the sharper the radius of bend, the less material needed for the bend allowance. The type of material is also important, for if the material is soft, it can be bent very sharply, but if hard, the radius of bend, and therefore the bend allowance, must be greater. The degree of bend affects the overall strength of the metal, whereas the thickness influences the bend radius.

Setback. When bending a piece of sheet stock, it is necessary to know the starting and ending points of the bend so that the length of the "flat" of the stock can be determined. Flats are the unbent sections of a formed part. Notice the location of the flats in figure 4-42. Two factors are important in determining the location of the flats: the radius of bend and the thickness of the material.

In figure 4-42, note that setback is the distance from the bend tangent line to the mold point. The mold point is the point of intersection of the lines extending from the outside surfaces, while the bend tangent lines are the starting and end points of the bend. Also note that setback is the same for the vertical flat and the horizontal flat.

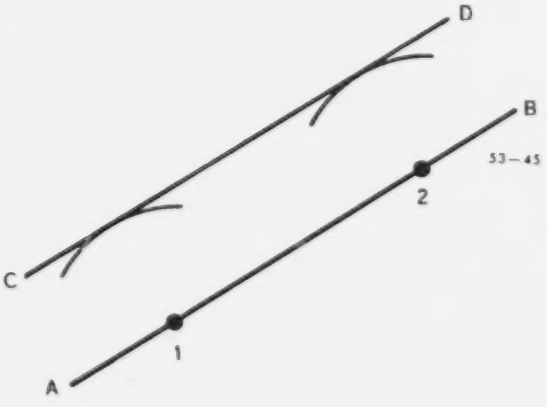
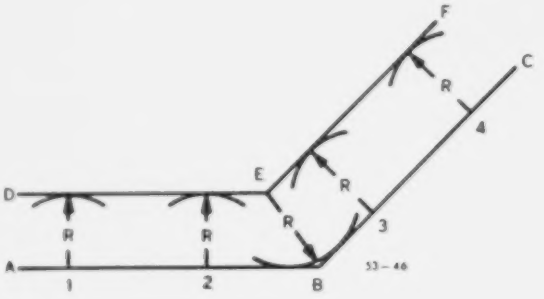


Figure 4-39. Constructing lines parallel to a line.



Exercises (256):

1. What is the difference between degree of bend and radius of bend?

2. Why is bend allowance calculated along the neutral axis of a piece of metal?

3. What is the term "mold point" and how is it used?

4. Why is it necessary to determine the amount of setback allowance?

5. How many setbacks are there in a 90° bend?

257. Using a bend allowance chart, a setback chart, and a table of decimal fraction equivalents, determine setback and flats dimensions and bend allowances for given forming situations.

When bending metal to exact dimensions, you must determine the length of the neutral line in order to allow sufficient material for the bend. To save you time in calculation of the bend allowance, formulas and charts for various angles, radii of bends, material thicknesses, and other factors have been established. Table 4-1, Bend Allowance Chart, Table 4-2, Setback (K) Chart, and Table 4-3, Decimal Equivalents of Fractions, are the three main tables you will use.

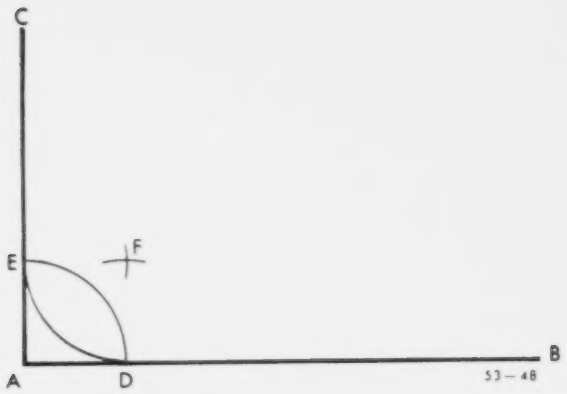


Figure 4-41. Constructing an arc of given radius within a right angle.

Bend Allowance Calculations. To determine bend allowance for any degree of bend by use of the bend allowance chart (Table 4-1), find the allowance per degree for the thickness of the material and the radius of bend in question, and then multiply by the number of degrees in the bend.

Radius of bend is given as a decimal fraction on the top line of the chart. Bend allowance is given directly below the radius figures. The top number in each case is the bend allowance for a 90° angle, while the lower placed number is for a 1° angle. Material thickness is given in the left column of the chart.

To find the bend allowance when the sheet thickness is 0.051 inch, the radius of bend is ¼ inch (0.250 inch), and the bend is 90°, look at the bend allowance chart (Table 4-1). Reading across the top of the chart, find the column for a radius of bend of 0.250 inch. Now find the block in this column that is opposite the gage of .050 in the column at left. The upper number in the block is .428, the correct bend allowance in inches for a 90° bend.

If the bend is to be other than 90°, you must use the lower number in the block (the bend allowance for 1°) and compute the bend allowance. The lower number in this case is .004756. Therefore, if the bend is to be 120°, your total bend allowance in inches will be 120 × .004756, or .5707 inch.

Setback Calculations. To calculate the setback for a 90° bend, merely add the inside radius of the bend to the thickness of the sheet stock. (Just remember the formula: SB = R + T.)

To calculate setback for angles larger or smaller than 90°, you have to consult setback charts (Table 4-2), also called K-charts, for a value called K and then substitute this value in the formula SB = K (R + T). The value for K varies with the number of degrees in the bend.

For a 90° bend, if the material is 0.051 inch thick and the radius of bend is specified to be ⅛ inch (0.125), substitute in the formula SB = R + T and solve as follows:

SB = 0.125 + 0.051 = 0.176-inch setback.

For a 120° bend with a radius of bend of 0.125 inch in a sheet 0.032-inch thick, obtain the value of K from the setback chart (K for 120° bend = 1.732), substitute in the formula SB = K(R + T) and solve as follows:

SB = 1.732(.032 + .125) = .272 inch

Assume that you are to lay out a flat pattern of a channel, as illustrated in figure 4-43, in which the left-hand flat, A, is to be 1-inch high; the right-hand flat, C, is to be 1¼ inches high; and the distance between the outside surface of the two flats, B, is to be 2 inches. The material is 0.051-inch thick, and the radius of bend is to be 3/16 inch (0.188). The angles are to be 90°. Let's go through the procedure step by step.

First determine the setback in order to establish the distance of the flats. (The setback for the first bend is R + T, or 0.188 + 0.051 = 0.239. The first flat, A, is equal to the overall dimension less the setback, or 1.000 – 0.239 = 0.761 inch.

Next calculate the bend allowance for the first bend by using the bend allowance table (BA = 0.331). Now lay off these measurements so you know where to begin and end each bend. (Refer to fig. 4-43 for illustration of the steps.)

Next lay off the second flat, B. This is equal to the overall dimension less the setback at each end, which is B minus *two* setbacks, or 2.000 – (0.239 + 0.239) = 2 – 0.478 = 1.522. The bend allowance for the second

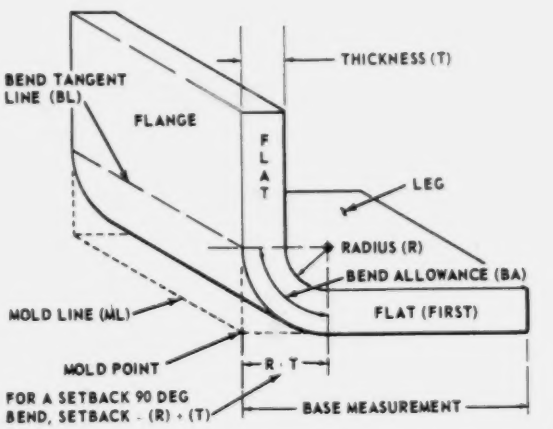


Figure 4-42. Bending terms.

bend is the same as that for the first bend (0.331). Mark off this distance. The third flat, C, is equal to the overall dimension less the setback, or 1.25 - 0.239 = 1.011. (Lay off this distance as illustrated in fig. 4-43.)

Add the measurements of flats A, B, and C, and both bend allowances (0.761 + 0.331 + 1.522 + 0.331 + 1.011), and you get 3.956, or approximately 4.00 inches. If you had simply added the three overall dimensions 1, 2, and 1¼ inches, you would have gotten a total of 4.250 inches of material length. You can see how setback and bend allowance affect material lengths in forming straight line bends. In this case, the reduction is approximately ¼ inch. (If the angles had not been right angles, you would have taken the setback values from setback or K charts.)

After you calculate all measurements, cut the material and mark off the brake or sight lines as shown in figure 4-43. You are ready to use the brake to form the channel.

Exercises (257):

Note: Refer to tables 4-1, 4-2, and 4-3 when answering the following questions. Round off your answers to three decimal places.

1. What is the bend allowance for a 90° bend of 3/16 inch radius if the sheet is .040 thick?

2. What is the bend allowance for a 7/32 inch radius bend of 50° in a sheet .070 thick?

3. What is the setback dimension for a 90° angle which is .032 thick and has a bend radius of 3/32?

4. What is the setback dimension for a 60° angle which is .064 thick and has a bend radius of ½?

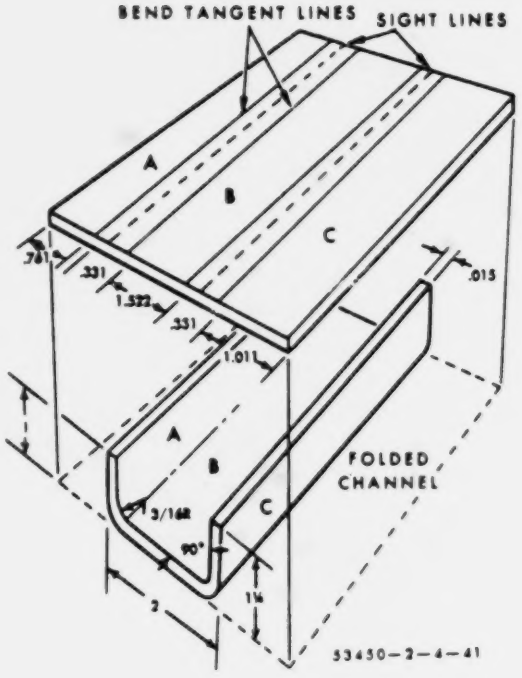


Figure 4-43. Flat layout of a channel.

TABLE 4-1
BEND ALLOWANCE CHART

RADIUS / GAGE	.063 = 1/16	.094 = 3/32	.125 = 1/8	.156 = 5/32	.188 = 3/16	.219 = 7/32	.250 = 1/4
.020	.113 .001251	.161 .001792	.210 .002333	.259 .002874	.309 .003433	.358 .003974	.406 .004515
.025	.116 .001294	.165 .001835	.214 .002376	.263 .002917	.313 .003476	.362 .004017	.410 .004558
.032	.121 .001345	.170 .001886	.218 .002427	.267 .002968	.317 .003526	.366 .004067	.415 .004608
.040	.127 .001411	.176 .001952	.224 .002493	.273 .003034	.323 .003593	.372 .004134	.421 .004675
.050	.134 .001413	.183 .002034	.232 .002575	.280 .003116	.331 .003675	.379 .004215	.428 .004756
.063	.144 .001595	.192 .002136	.241 .002676	.290 .003218	.340 .003776	.389 .004317	.437 .004858
.070		.198 .002202	.247 .002743	.296 .003284	.346 .003842	.394 .004283	.443 .004924
.080		.204 .002272	.253 .002813	.302 .003354	.352 .003912	.401 .004453	.449 .004969
.090		.212 .002350	.260 .002891	.309 .003432	.359 .003990	.408 .004531	.456 .005072
.100			.268 .002977	.317 .003518	.367 .004076	.416 .004617	.464 .005158
.125			.284 .003156	.333 .003697	.383 .004256	.432 .004797	.480 .005338
.156				.355 .003939	.405 .004497	.453 .005038	.502 .005579
.190					.417 .004747	.476 .005286	.525 .005829
.250							.568 .006313

NOTE: Top number in each box is Bend Allowance for 90° bend.

Bottom number in each box is Bend Allowance for 1° bend. Do not round off the bottom number.

53-1315

TABLE 4-2
SETBACK (K) CHART

ANGLE DEGREES	K-Value	ANGLE DEGREES	K-Value	ANGLE DEGREES	K-Value	ANGLE DEGREES	K-Value
1	.00873	46	.42447	91	1.0176	136	2.4751
2	.01745	47	.43481	92	1.0355	137	2.5386
3	.02618	48	.44523	93	1.0538	138	2.6051
4	.03492	49	.45573	94	1.0724	139	2.6746
5	.04366	50	.46631	95	1.0913	140	2.7475
6	.05241	51	.47697	96	1.1106	141	2.8239
7	.06116	52	.48773	97	1.1303	142	2.9042
8	.06993	53	.49858	98	1.1504	143	2.9887
9	.07870	54	.50952	99	1.1708	144	3.0777
10	.08749	55	.52057	100	1.1917	145	3.1717
11	.09629	56	.53171	101	1.2131	146	3.2708
12	.10510	57	.54295	102	1.2349	147	3.3759
13	.11393	58	.55431	103	1.2572	148	3.4874
14	.12278	59	.56577	104	1.2799	149	3.6059
15	.13165	60	.57735	105	1.3032	150	3.7320
16	.14054	61	.58904	106	1.3270	151	3.8667
17	.14945	62	.60086	107	1.3514	152	4.0108
18	.15838	63	.61280	108	1.3764	153	4.1653
19	.16734	64	.63487	109	1.4019	154	4.3315
20	.17633	65	.63707	110	1.4281	155	4.5107
21	.18534	66	.64941	111	1.4550	156	4.7046
22	.19438	67	.66188	112	1.4826	157	4.9151
23	.20345	68	.67451	113	1.5108	158	5.1455
24	.21256	69	.68728	114	1.5399	159	5.3995
25	.22169	70	.70021	115	1.5697	160	5.6713
26	.23087	71	.71329	116	1.6003	161	5.9758
27	.24008	72	.72654	117	1.6318	162	6.3137
28	.24933	73	.73996	118	1.6643	163	6.6911
29	.25862	74	.75355	119	1.6977	164	7.1154
30	.26795	75	.76733	120	1.7320	165	7.5957
31	.27732	76	.78128	121	1.7675	166	8.1443
32	.28674	77	.79543	122	1.8040	167	8.7769
33	.29621	78	.80978	123	1.8418	168	9.5144
34	.30573	79	.82434	124	1.8807	169	10,3850
35	.31530	80	.83910	125	1.9210	170	11.4300
36	.32492	81	.85408	126	1.9626	171	12.7060
37	.33459	82	.86929	127	2.0057	172	14.3010
38	.34433	83	.88472	128	2.0503	173	16.3500
39	.35412	84	.90040	129	2.0965	174	19.0810
40	.36397	85	.91633	130	2.1445	175	22.9040
41	.37388	86	.93251	131	2.1943	176	26.6360
42	.38386	87	.94896	132	2.2460	177	38.1880
43	.39391	88	.96596	133	2.2998	178	57.2900
44	.40403	89	.98270	134	2.3558	179	
45	.41421	90	1.00000	135	2.4142	180	

Note: Do not round off the K value.

53-1316

TABLE 4-3
DECIMAL EQUIVALENTS OF FRACTIONS

FRACTION	16 TH.	32 ND.	64 TH.	DECIMAL
			1	.015625
		1	2	.03125
			3	.046875
	1	2	4	.0625
			5	.078125
		3	6	.09375
			7	.109375
1/8	2	4	8	.125
			9	.140625
		5	10	.15625
			11	.171875
	3	6	12	.1875
			13	.203125
		7	14	.21875
			15	.234375
1/4	4	8	16	.250
			17	.265625
		9	18	.28125
			19	.296875
	5	10	20	.3125
			21	.328125
		11	22	.34375
			23	.359375
3/8	6	12	24	.375
			25	.390625
		13	26	.40625
			27	.421875
	7	14	28	.4375
			29	.453125
		15	30	.46875
			31	.484375
1/2	8	16	32	.500

FRACTION	16 TH.	32 ND.	64 TH.	DECIMAL
			33	.515625
		17	34	.53125
			35	.546875
	9	18	36	.5625
			37	.578125
		19	38	.59375
			39	.609375
5/8	10	20	40	.625
			41	.640625
		21	42	.65625
			43	.671875
	11	22	44	.6875
			45	.703125
		23	46	.71875
			47	.734375
3/4	12	24	48	.750
			49	.765625
		25	50	.78125
			51	.796875
	13	26	52	.8125
			53	.828125
		27	54	.84375
			55	.859375
7/8	14	28	56	.875
			57	.890625
		29	58	.90625
			59	.921875
	15	30	60	.9375
			61	.953125
		31	62	.96875
			63	.984375
1	16	32	64	1.000

53-1334

Metal Forming

ONCE YOU HAVE determined the working dimensions of piece or part to be attached to aircraft, you have two basic ways of developing the item from paper to metal. You bend and form the metal by hand, or else you do it by machine.

In the first part of this chapter, we discuss hand forming and the necessary tools to do a proper job of it. Hand forming requires the best of your knowledge and skills as an airframe repairman since hand forming usually involves the use of extremely light-gage alloys. These delicate light-gage materials can quickly be made useless by coarse and careless workmanship. In hand forming, use hammers and mallets as sparingly as practicable.

In the last part of this chapter, we discuss the construction, operation, and maintenance of some of the machines necessary for forming and folding metal into usable parts. We include the bar folder, cornice brake, box and pan brake, slip roll former, flanging machines, shrinking and stretching machines, and the arbor press.

5-1. Hand Forming

258. Define or describe four basic hand forming operations.

The methods you use in hand forming operations include such sheet metal processes as bumping, crimping, stretching, and shrinking.

Bumping. Bumping is the term applied to forming or shaping metal by hammering or pounding. Bumping can only be done on malleable metals, that is, on metals that are capable of being extended or stretched. Bumping can be done either by hand or by machine. During the bumping process, the metal is supported or backed up with a smooth face dolly, sandbag, or die. As the shape of the desired part varies greatly, many types, sizes, and shapes of dolly blocks and dies are used.

Crimping. The forming on the edges of sheet metal by pleating, folding laps, or corrugating is called crimping. Crimping is often used to make one end of a section of pipe slightly smaller so that it will slip-fit into the plain end of a similar section of pipe. Turning down a flange on a seam or the use of crimping pliers will cause the metal to curve. Some crimping and stretching measures are shown in figure 5-1. The effect of the crimping tool is exaggerated for clarity in the intermediate step.)

Stretching. Metal may be stretched by several methods. On ordinary pieces of flat metal, the most common method is to force the metal outward toward the edges by hammering on areas supported by an anvil or similar base support. As the hammering force is applied, the metal in that area becomes thinner. However, since the amount of metal does not decrease, it must cover a greater area, which results in stretching at this point. Stretching one portion of a piece of sheet metal affects the surrounding area, especially in the case of formed and extruded angles. For example, hammering the metal in the horizontal flange of the angle strip over a metal block, as shown in figure 5-1, forces the metal to spread; therefore, that section becomes longer than the section near the bend. In figure 5-2, the hammered area of line A has stretched, and the area of line B has curved. To compensate for the difference in length of the horizontal flange and the vertical flange in this case, the vertical flange, which tends to keep the material near the bend from stretching, is forced to curve away from the greater length.

Shrinking. Shrinking, as the name implies, refers to the reduction of an area of a piece of metal. Thus, the shrinking process is compressing or forcing material into a smaller area. This operation is used to develop curves or straighten flat pieces. For example, if a piece of metal has been stretched too far, the metal must be shrunk to the desired shape. Whereas stretching thins the metal, shrinking thickens it.

Exercises (258):

1. Define the forming term "bumping."

2. Why would you crimp metal?

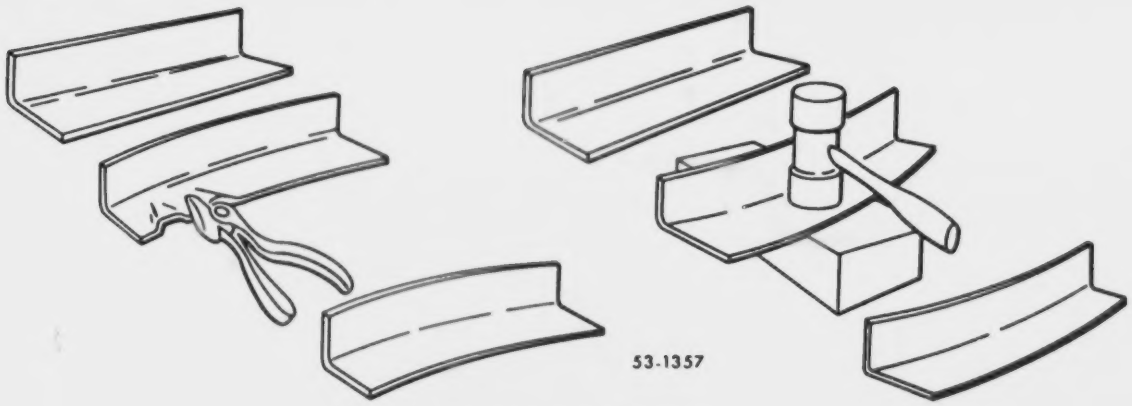


Figure 5-1. Crimping and stretching.

3. Describe the common method used to stretch a flat piece of metal.

4. Describe the shrinking process.

259. Given a hand forming situation, describe the proper equipment to use.

The efficient forming and processing of metal in various shapes requires support, forms, and holding devices. Metal and wood forming blocks, stakes, and sandbags are tools that can be used for this task.

V-Blocks. V-blocks made of hardwood are widely used in airframe metalwork for shrinking and stretching metal, particularly angles and flanges. The size of the block depends on the work being done and on personal preference. Although any type of hardwood is suitable, maple and ash are recommended for best results when working with aluminum alloys.

Hardwood Form Blocks. Hardwood form blocks can be constructed to duplicate practically any aircraft part, structural or nonstructural. The curved angle strip, shown in figure 5-3, has been formed with the use of form blocks. The wooden block or form shown in figure 5-3 is shaped to the exact dimensions and contour of the part to be formed. When shaping the blocks, do the rough work with ordinary wood saws, chisels, gouges, files, and rasps, and perform the final smoothing with sandpaper. Since the form must be accurate, prepare several templates so that you can test the accuracy of the form at frequent intervals. If the forms are to be used over a period of time, apply several coats of shellac to the blocks to keep them from checking, cracking, or shrinking.

Shrinking Blocks. A shrinking block consists of two metal blocks and some device for clamping them together. One block forms the base and the other is cut away to provide space where the crimped material can be hammered. The legs of the upper jaw clamp the material to the base block on each side of the crimp so that the material will not creep away, but will remain stationary while the crimp is hammered flat (being shrunk). This type of crimping block is designed to be held in a bench vise. Shrinking blocks can be made to fit any specific need. The basic form and principle remain the same, even though the blocks may vary considerably in size and shape.

Sandbags. A sandbag is usually used as a support during the bumping process. A serviceable bag can be made by sewing heavy canvas or soft leather to form a bag of the desired size, and filling it with sand which has been sifted through a fine mesh screen. Unless a heavy duty sewing machine is available, sew the bag by hand, using a heavy cord. (The seam made by an ordinary sewing machine is not strong enough.) Before filling the bag with sand, use a brush to coat the inside of it with heated paraffin or beeswax, which forms a sealing layer and prevents the sand from working through the pores of the canvas.

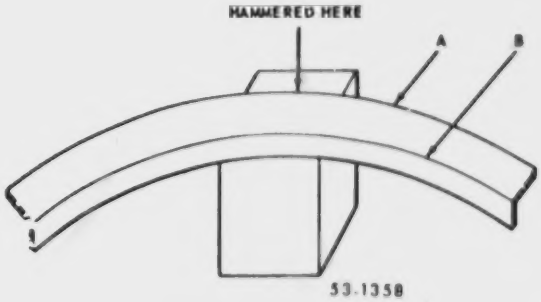


Figure 5-2. Stretching results.

300 A

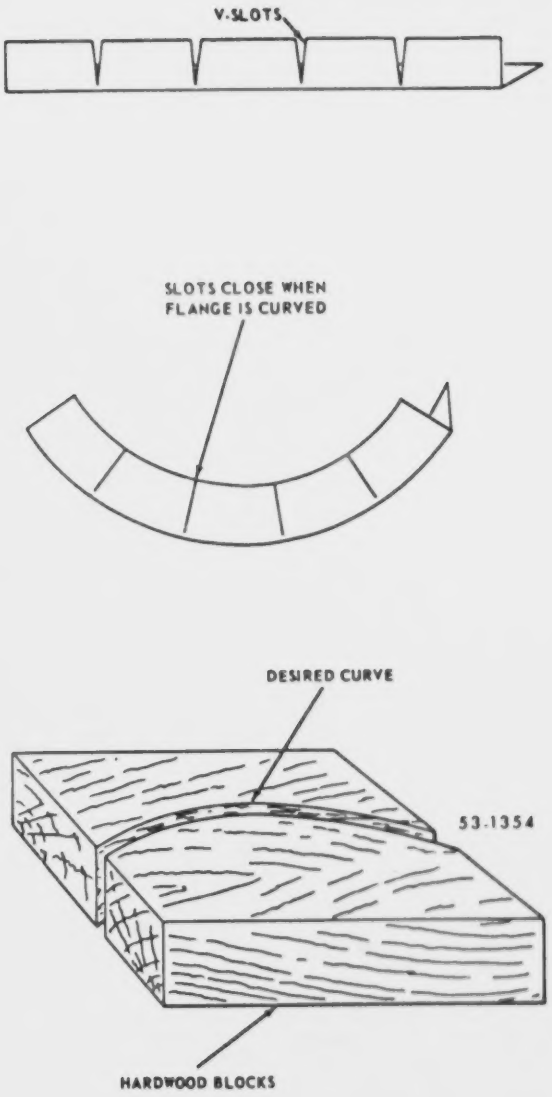


Figure 5-3. Hardwood form block.

Dolly Blocks. Dolly blocks, sometimes called anvils, are iron body blocks with smooth surfaces. Dolly blocks (several are shown in fig. 5-4) have various shapes which make them easily adaptable for many uses in repairing aircraft metal. Dolly blocks are designed to be held by hand and against the surface to be worked.

Stakes. Sheet metal is often formed or finished (planished) over various shaped anvils called stakes. These are used for forming small, odd-shaped parts, or for putting on finishing touches, for which a large machine may not be suited. Stakes are designed to be supported by a flat cast iron bench plate fastened to the workbench. (See fig. 5-5).

Most stakes have machined, polished surfaces which have been hardened. Do not use stakes to back up material when chiseling, or when using any similar cutting tool, as this defaces the surface of the stake and makes it useless for finish work.

Square stakes. Three types of square stakes—the common square stake, the coppersmith square stake, and the bevel-edge square stake—are for general sheet metalwork. The coppersmith stake is offset, permitting a greater variety of applications.

Double-seaming stake (simple). The double-seaming stake has two horns with elongated heads. It is used as a support when laying down double seams on small cylindrical objects.

Roundhead stake. The roundhead stake is not used extensively. However, its curved head makes it quite suitable for forming curved and irregularly shaped objects.

Bottom stake. The bottom stake has a flared end and is used for dressing down an object having a burred or flanged circular bottom.

Needle case stake. The needle case stake has a round, tapered horn for forming small rings and tubular objects, and a heavier rectangular horn on which square work can be formed.

Conductor stake. The conductor stake has two cylindrical horns of different diameters. It is for forming, seaming, and riveting pipes and elbows, especially those with small diameters.

Candle mold stake. The candle mold stake has a horn of rather large diameter on one end, and a long, tapered horn at the other. The larger horn is used for general purposes, and the smaller one is for reshaping and for tube forming.

Hatchet stake. The hatchet stake has a beveled horizontal bar. It is used for making straight bends as well as for folding and bending edges. Flanging and dovetailing may also be done on it.

Double-seaming stake (four heads). This double-seaming stake has two shanks and four interchangeable heads. This arrangement permits it to be used for several different positions and conditions. It is suitable for all kinds of riveting and for double seaming of large objects.

Creasing stake. The creasing stake has a tapered horn on one end for shaping conical objects. A creased mandrel on the other end permits, bending, wiring, and turning operations.

Beak horn stake. A round, tapered horn on one end and a square, tapered horn on the other make the beak horn stake adaptable for general sheet metalwork and shaping, and for riveting round and square objects.

Blowhorn stake. The blowhorn stake has a large, tapered end, called an apron, which is used for shaping objects with abrupt tapers, such as funnels. The other end of the stake is round and has a long, narrow taper for forming slightly tapered objects. It can also be used to form metal or wire into rings of small diameter.

Solid mandrel stakes. Solid mandrel stakes are available in 30-, 34½-, and 40-inch lengths. Each has the double shank on one end. In general, this stake is used for riveting, forming, and seaming square or rectangular material.

300 B

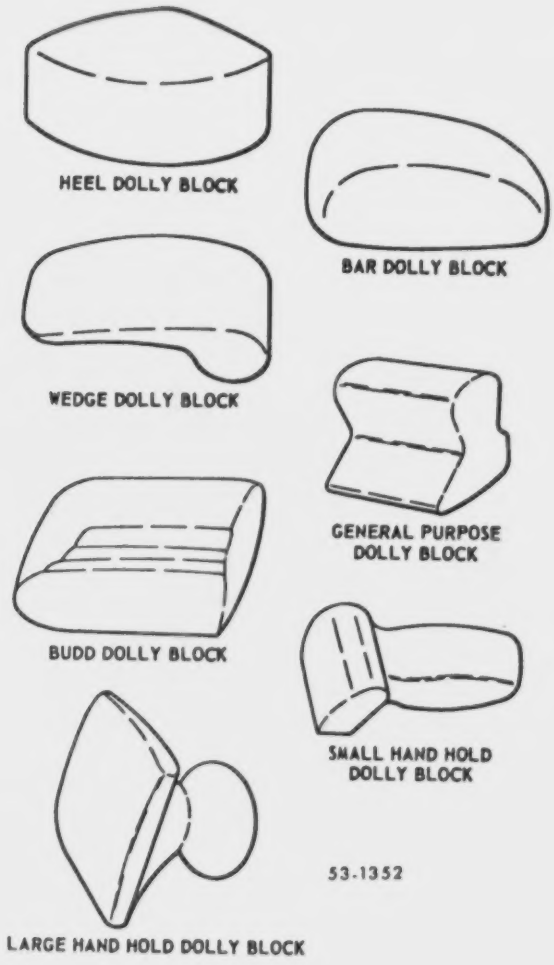


Figure 5-4. Dolly block.

Hollow mandrel stake. The hollow mandrel stake has a slot on the lower side in which a large bolt slides, making it possible to fasten the stake securely in any desired position on the bench. This stake comes in overall lengths of either 40 or 60 inches. It has a square section at one end and a rounded mandrel on the other, which makes it suitable for riveting, forming, and seaming.

Holding Devices. Vises and clamps are tools used for holding materials of various kinds on which some type of operation is being performed. The type of operation and the type of metal being used determine which holding device to use.

Vises. The most commonly used types of vises are shown in figure 5-6. The machinist's vise has flat jaws and usually a swivel base, whereas the utility bench vise has scored, removable jaws and an anvil-faced back jaw. The utility vise holds heavier material than the machinist's vise and also grips pipe or rod firmly. The back jaw can be used for an anvil on light work.

C-clamps. The carriage, clamp, or C-clamp as it is commonly called, is shaped like a large C and has three main parts—the threaded screw, the jaw, and the swivel head. The swivel plate which is on the end of the screw, prevents the end from turning directly against the material being clamped. C-clamps vary in size from 2 inches upward, and their function is always that of clamping or holding.

The shape of the C-clamp allows it to span obstructions near the edge of a piece of work. The greatest limitation in the use of the carriage clamp is its tendency to spring out of shape. Never tighten it more than hand tight.

Exercises (259):

1. What type of hardwood material is recommended for fabricating form blocks when forming aluminum?

2. If you had to form a piece of metal by crimping, what type of forming blocks would you select?

3. What is usually used for support during the forming process of bumping?

4. Identify the correct stake to be used for the forming operations stated by placing the name of the stake in space provided.

   _____ a. Riveting pipes and elbows.
   _____ b. Support when laying down double seams on small cylindrical objects.
   _____ c. For tube forming.
   _____ d. For forming irregularly shaped objects.
   _____ e. For making straight line bends.

5. If you had to cut a 6-foot pipe into three equal parts, what type of holding devices would you use during the cutting operation?

260. Describe significant details of the steps in shrinking and stretching formed and extruded angles.

Both formed and extruded angles can be curved (not bent sharply) by stretching or shrinking either of the flanges. Curving by stretching one flange is usually

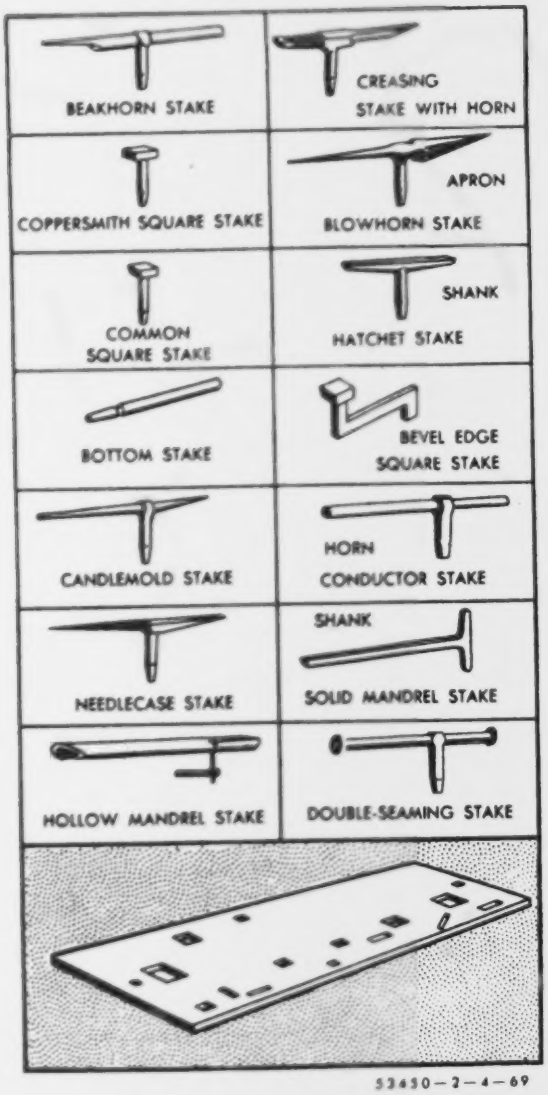


Figure 5-5. Bench plate and stakes.

preferred, since this process requires only a V-block and a mallet and is very easy.

Stretching a Flange. In the stretching process, place the flange to be stretched in the groove of the V-block. Using a stretching mallet, strike the flange directly over the V-portion with light, even blows and gradually force it downward into the V. A blow that is too heavy will buckle the angle strip. Keep moving the angle strip across the V-block, but always strike the spot directly above the V, as shown in the lower part of figure 5-7.

Form the curve gradually and evenly by moving the strip slowly back and forth, distributing the hammer blows at equal spaces on the flange.

Lay out a full-sized, accurate pattern on a sheet of paper or plywood and periodically check the accuracy of the curve. By comparing the angle with the pattern, you can tell exactly how the curve is progressing and just where it needs to be increased or decreased. It is better to get the curve to conform roughly to the desired shape before attempting to finish any one portion, because the finishing or smoothing of one portion of the angle may cause some other portion of the angle to change shape. If any part of the angle strip is curved too much, reduce the curve by reversing the angle strip on the V-block, placing the bottom flange up, and striking it with light blows of the mallet.

Try to form the curve with a minimum amount of hammering, for excessive hammering will work-harden the metal. Work-hardening can be recognized by a lack of bending response or by springiness in the metal. It can be recognized very readily by the experienced worker. In some cases, you may have to anneal the part during the curving operation. If you do, be sure to heat-treat the part again before installing it on the aircraft.

Shrinking a Flange. You can curve an extruded or formed angle strip by either of two methods of shrinking, the V-block method or the shrinking block method. Of the two, the V-block method is usually more satisfactory because it is faster, easier, and affects the metal less. However, very good results can be obtained by the shrinking block method.

In the V-block method, place one flange of the angle strip on the V-block with the other flange extending upward, as shown in figure 5-8. Hold it firmly so that it does not bounce when hammered, and strike the edge of the upper flange with light blows of a round, soft-faced mallet. Begin at one end of the angle strip and, moving the strip back and forth, strike light blows directly over the V-portion of the block. Strike the edge of the flange at a slight angle, as this tends to keep the vertical flange from bending outward.

Occasionally check the curve for accuracy with the pattern. If a sharp curve is made, the angle (cross

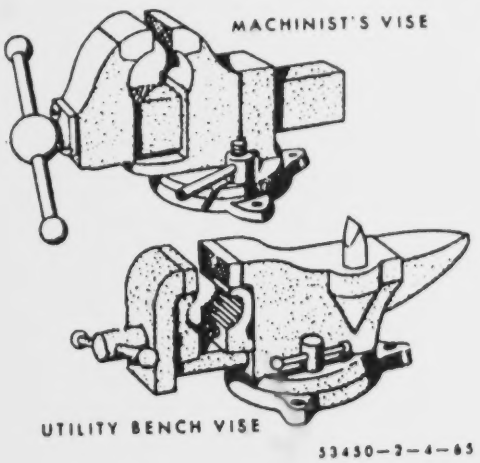


Figure 5-6. Vises.

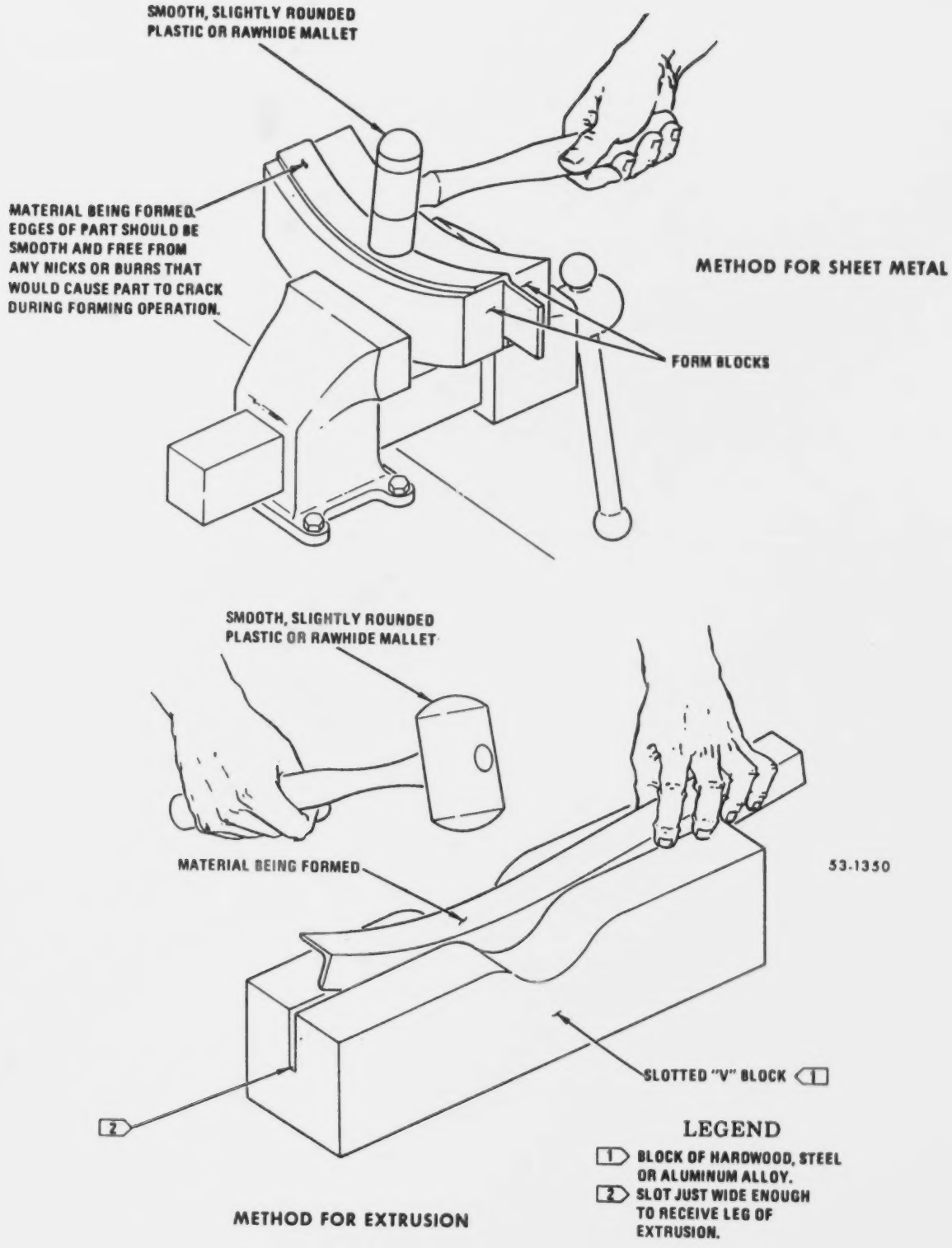

SMOOTH, SLIGHTLY ROUNDED PLASTIC OR RAWHIDE MALLET
MATERIAL BEING FORMED. EDGES OF PART SHOULD BE SMOOTH AND FREE FROM ANY NICKS OR BURRS THAT WOULD CAUSE PART TO CRACK DURING FORMING OPERATION.
METHOD FOR SHEET METAL
FORM BLOCKS
SMOOTH, SLIGHTLY ROUNDED PLASTIC OR RAWHIDE MALLET
MATERIAL BEING FORMED
53-1350
SLOTTED "V" BLOCK 1
2
LEGEND
1 BLOCK OF HARDWOOD, STEEL OR ALUMINUM ALLOY.
2 SLOT JUST WIDE ENOUGH TO RECEIVE LEG OF EXTRUSION.
METHOD FOR EXTRUSION

Figure 5-7. Hand forming concave surfaces.

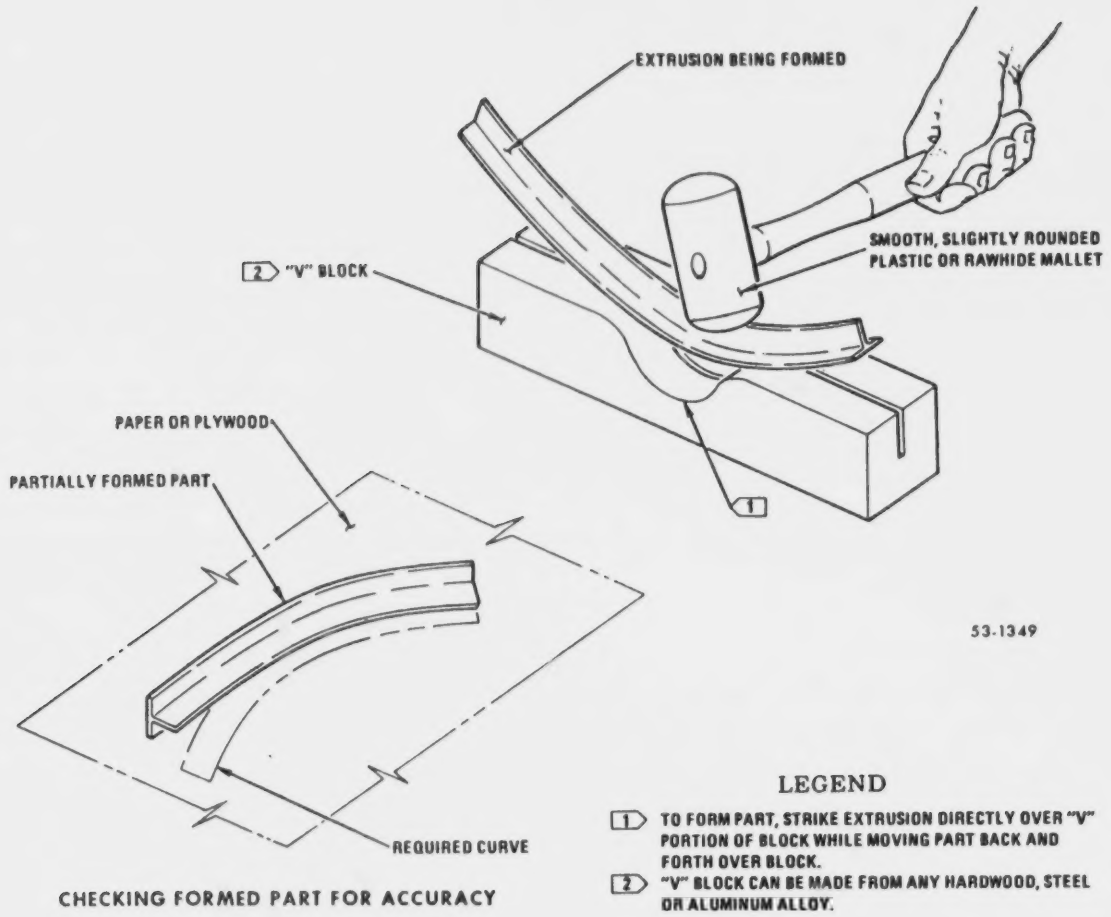

EXTRUSION BEING FORMED
SMOOTH, SLIGHTLY ROUNDED PLASTIC OR RAWHIDE MALLET
2 "V" BLOCK
PAPER OR PLYWOOD
PARTIALLY FORMED PART
1
53-1349
REQUIRED CURVE
CHECKING FORMED PART FOR ACCURACY
LEGEND
1 TO FORM PART, STRIKE EXTRUSION DIRECTLY OVER "V" PORTION OF BLOCK WHILE MOVING PART BACK AND FORTH OVER BLOCK.
2 "V" BLOCK CAN BE MADE FROM ANY HARDWOOD, STEEL OR ALUMINUM ALLOY.

Figure 5-8. Hand forming extruded shapes.

section of the formed angle) will close slightly. To avoid such closing of the angle, clamp the angle strip to a hardwood board with the hammered flange facing upward. Use small C-clamps, on which the jaws have been covered with masking tape. If the angle has already closed, you can bring the flange back to the correct angle with a few blows of a mallet or with the aid of a small hardwood block. If any portion of the angle strip is curved too much, reduce it by reversing the angle on the V-block and hammering with a suitable mallet, as previously explained for stretching. When you have obtained the proper curve, smooth the entire angle by planishing with a soft-faced mallet.

If the curve in a formed angle is to be quite sharp or if the flanges of the angle are rather broad, you have to use the shrinking block method. In this process, crimp the flange which is to form the inside of the curve.

When making a crimp, hold the crimping pliers so that jaws are about ⅛ inch apart. By rotating the wrist back and forth, bring the upper jaw of the pliers into contact with the flange, first on one side and then on the other side of the lower jaw. Complete the crimp by working a raised position into the flange, gradually increasing the twisting motion of the pliers. Do not make the crimp too large, as it will be difficult to work out. The size of the crimp depends upon the thickness and softness of the material, but usually about ¼ inch is sufficient. Place several crimps spaced evenly along the desired curve with enough space left between each crimp so that jaws of the shrinking block can be easily attached.

After completing the crimping, place the crimped flange in the shrinking block so that one crimp at a time is located between the jaws. Flatten each crimp with light blows of a soft-faced mallet, starting at the apex (the closed end) of the crimp and gradually working toward the edge of the flange. Check the curve of the angle with the pattern periodically during the forming process and again after all the crimps have been worked out. If it is necessary to increase the curve, add more crimps and repeat the process. Space

the additional crimps between the original ones so that the metal will not become unduly work-hardened at any one point. If the curve needs to be increased or decreased slightly at any point, use the V-block. After obtaining the desired curve, planish the angle strip over a stake or a wooden form.

Exercises (260):

1. When stretching a flange using a V-block, where should you hammer the metal?
2. How can you insure that you don't overform a flange when stretching an extruded angle on a V-block?
3. How can you recognize when a piece of metal being formed is work-hardening?
4. Why is the V-block method of shrinking a flange preferred over the shrinking block method?
5. When using a V-block to shrink a flange, in what direction do you point the flange to be shrunk?
6. Why is it recommended that you strike the edge of the flange at a slight angle when shrinking a flange on a V-block?
7. When would you use the shrinking block method of shrinking a flange?
8. What factors determine the size of a crimp?
9. Why is it recommended that the crimps be kept as small as possible?
10. If you perform a second crimping process to complete the job, where do you position additional crimps?

261. Describe key procedures used to form flanged angles.

The forming process for the following two flanged angles is slightly more complicated than that just discussed because the bend is shorter (not gradually curved) and necessitates shrinking or stretching in a small or concentrated area. If the flange is to point toward the inside of the bend, the material must be shrunk. If it is to point toward the outside, it must be stretched.

Forming by Shrinking. In forming a flanged angle by shrinking, use wooden form blocks similar to those shown in figure 5-9 and proceed as follows:

1. Cut the metal to size, allowing for trimming after forming. Determine bend allowance for a 90° bend and round the edge of the forming block accordingly.
2. Clamp the material in the form blocks as shown in figure 5-9 and bend the exposed flange against the block. After bending, tap the blocks slightly. (This induces a setting process in the bend.)
3. Using a soft-faced shrinking mallet, start hammering near the center and work the flange down gradually toward both ends. The flange will tend to buckle at the bend because you are forcing the material to occupy less space. Work the material into several small buckles instead of one large one, and work each small buckle out gradually by hammering lightly and gradually compressing the material in each buckle. A small hardwood wedge block (as shown in fig. 5-9) helps in working out the buckles.
4. Planish the flange after it is flattened against the form block, and remove small irregularities. If the form blocks are made of hardwood, use a metal planishing hammer; if the forms are made of metal, use a soft-faced mallet. Trim the excess material away and file and polish.

Forming by Stretching. To form a flanged angle by stretching, use the same forming blocks, wooden wedge block, and mallet as in the shrinking process. Proceed as follows:

1. Cut the material to size (allowing for trim), determine bend allowance for a 90° bend, and round off the edge of the block to conform to the desired radius of bend.
2. Clamp the material in the form blocks as shown in figure 5-9.
3. Using a soft-faced stretching mallet, start hammering near the ends and work the flange down smoothly and gradually to prevent cracking and splitting. Planish the flange and angle, as in the previous procedure, and trim and smooth the edges as necessary.

Exercises (261):

1. If you form a flanged angle with the flange pointed toward the inside of the bend, what must you do to the metal on the flange?

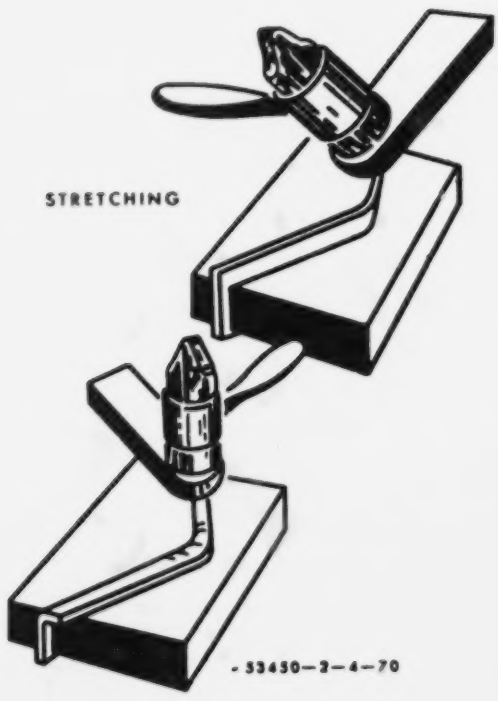


Figure 5-9. Forming a flanged angle.

2. What type of blocks do you use when flanging angles?

3. Where do you start hammering when forming a flanged angle by shrinking?

4. What effect has the material composition of the form block on the type hammer used?

5. How does the hammering procedure for forming a flange angle by stretching differ from that required for shrinking?

262. Explain the techniques used to form concave and convex flanges.

Curved Flanged Parts. Curved flanged parts are usually hand formed. Of the parts shown in figure 5-10, the one with relief holes (lower right) is probably the simplest to form. It has a concave flange (the inside flange) and a convex flange (the outside flange).

The concave flange is formed by stretching; the convex flange by shrinking. Such parts may be formed with the aid of hardwood or metal forming blocks. These blocks are made in pairs similar to those used for straight angle bends and are identified in the same manner. They differ in that they are made specifically for the particular part to be formed, they fit each other exactly, and they conform to the actual dimensions and contour of the finished article.

The mating parts may be equipped with aligning pins to aid in lining up the blocks and holding the metal in place. The blocks may be held together by C-clamps or a vise. They also may be held together with bolts by drilling through both forms and the metal, provided the holes do not affect the strength of the finished part. The edges of the forming blocks are rounded to give the correct radius of bend to the part, and are undercut to allow for springback of the metal. The undercut is especially important and necessary if the material is hard or if the bend must be highly accurate.

Note the various types of forming represented in figure 5-10. In the plain nose rib (upper left), only one large convex flange is used; but, because of the great distance around the part and the likelihood of buckles in forming, it is rather difficult to form. The flange and the beaded portion of this rib provide sufficient strength to make this a very good type to use. In the

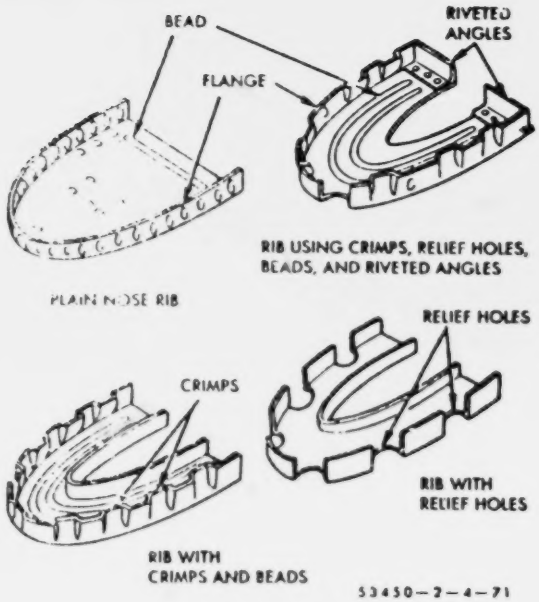


Figure 5-10. Nose ribs.

type with relief holes, the concave flange gives difficulty in forming; however, the outside flange is broken up into smaller sections by relief holes (notches inserted to prevent strains in a bend). In the type with crimps and beads (lower left), note that crimps are inserted at equally spaced intervals. The crimps are placed to absorb material and cause curving, and to give strength to the part.

In the fourth nose rib illustrated (upper right), note that all of the four common forming methods are applied. They are crimping, bending, putting in relief holes, and using a formed angle riveted on each end. The bends and formed angles supply strength for the part.

Forming Techniques. In forming a curved flange part, cut the material to size (allowing for trim), locate and drill holes for alignment pins, and remove all burrs (jagged edges). Place the material between the wooden blocks. Clamp the blocks tightly in a vise so that the material cannot move or shift. Clamp the work as closely as possible to the particular part being hammered, to prevent strain on the form blocks and to keep the metal from slipping. (See fig. 5-11).

Bend the flange on the concave curve first. This practice helps keep the flange from splitting open or cracking when the metal is stretched. (Should this occur, a new piece of material will have to be used.) Using a soft mallet or wooden wedge block, start hammering at a point a short distance away from the beginning of the concave bend and continue toward the center of the bend. This procedure permits some of the excess metal along the tapered portion of the flange to be worked into the curve where it will be needed. Continue hammering until the metal is gradually worked down over the entire flange, flush with the form block. (See upper portion of fig. 5-7).

Starting at the center of the curve and working toward both ends, hammer the convex flange down over the form. (See fig. 5-12.) Strike the metal with glancing blows, at an angle of approximately 30° off perpendicular, and away with a motion that will tend to pull the part away from the block.

Stretch the metal around the radius bend and remove the buckles gradually by hammering on a wedge block. While you work the metal down over the form, keep the edges of the flange as nearly perpendicular to the block as possible. The wedge block helps keep the edge of the metal perpendicular to the block, lessens the possibility of buckles and of splitting or cracking the metal, and aids in removing buckles. Finally, trim the flanges of excess metal, planish, remove burrs, round the corners (if any), and check the part for accuracy.

Exercises (262):

1. When forming curved parts, why is the concave curve formed first?

2. Why is it necessary to hammer at the ends, working toward the middle, when forming curved concaved flanges?

3. What procedure can you follow to lessen the possibility of buckles and splitting or cracking, when forming curved convex flanges?

4. Where do you start hammering when forming curved convex flanges?

5. Why is one form block undercut when forming curved concave and convex flanges?

6. What is used to keep the metal being formed from shifting within the form blocks during the forming operation?

7. What must you do to the metal to form concave flanges?

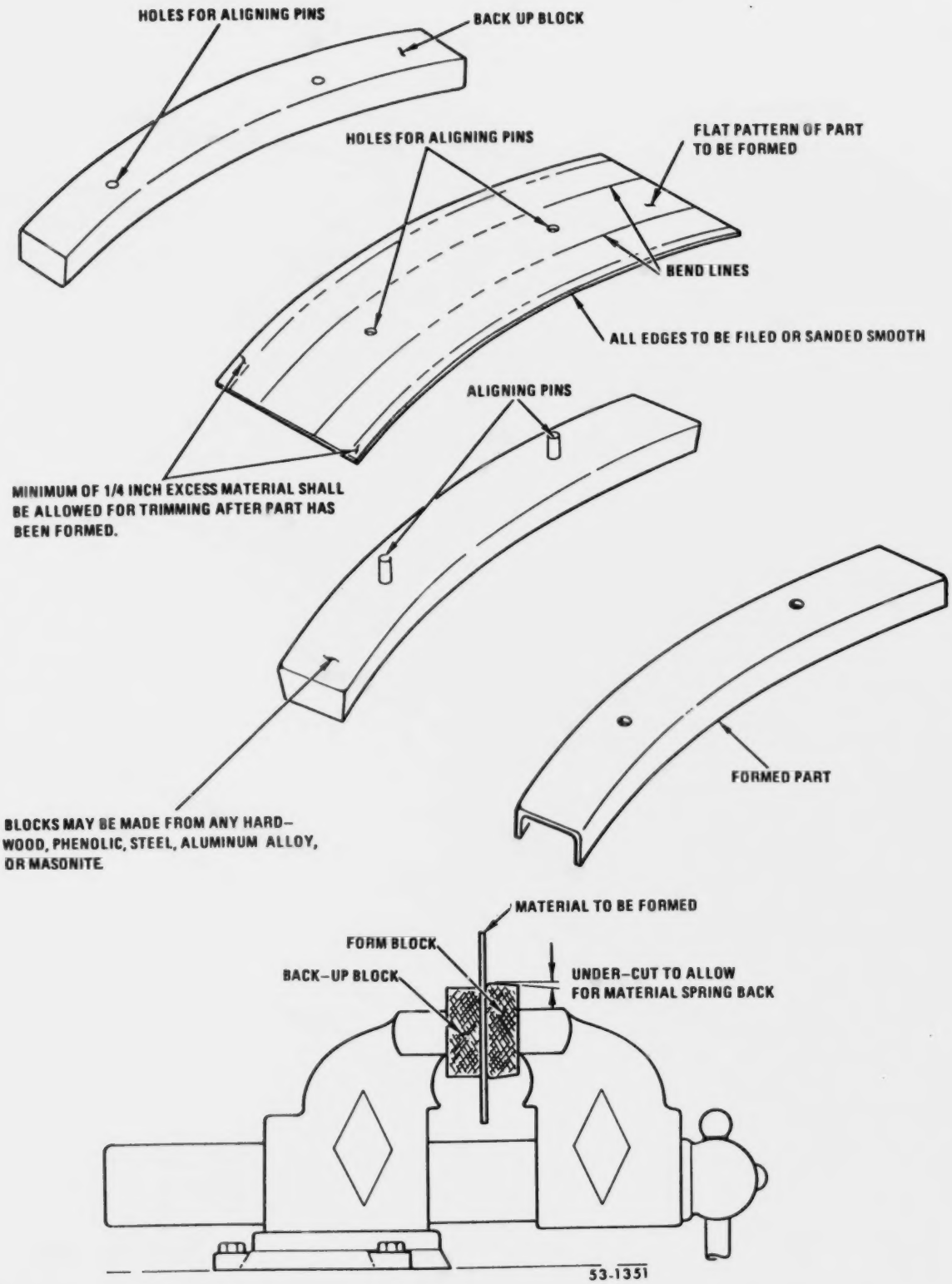

HOLES FOR ALIGNING PINS
BACK UP BLOCK
HOLES FOR ALIGNING PINS
FLAT PATTERN OF PART TO BE FORMED
BEND LINES
ALL EDGES TO BE FILED OR SANDED SMOOTH
ALIGNING PINS
MINIMUM OF 1/4 INCH EXCESS MATERIAL SHALL BE ALLOWED FOR TRIMMING AFTER PART HAS BEEN FORMED.
FORMED PART
BLOCKS MAY BE MADE FROM ANY HARD-WOOD, PHENOLIC, STEEL, ALUMINUM ALLOY, OR MASONITE.
MATERIAL TO BE FORMED
FORM BLOCK
BACK-UP BLOCK
UNDER-CUT TO ALLOW FOR MATERIAL SPRING BACK
53-1351

Figure 5-11. Material and form block alignment.

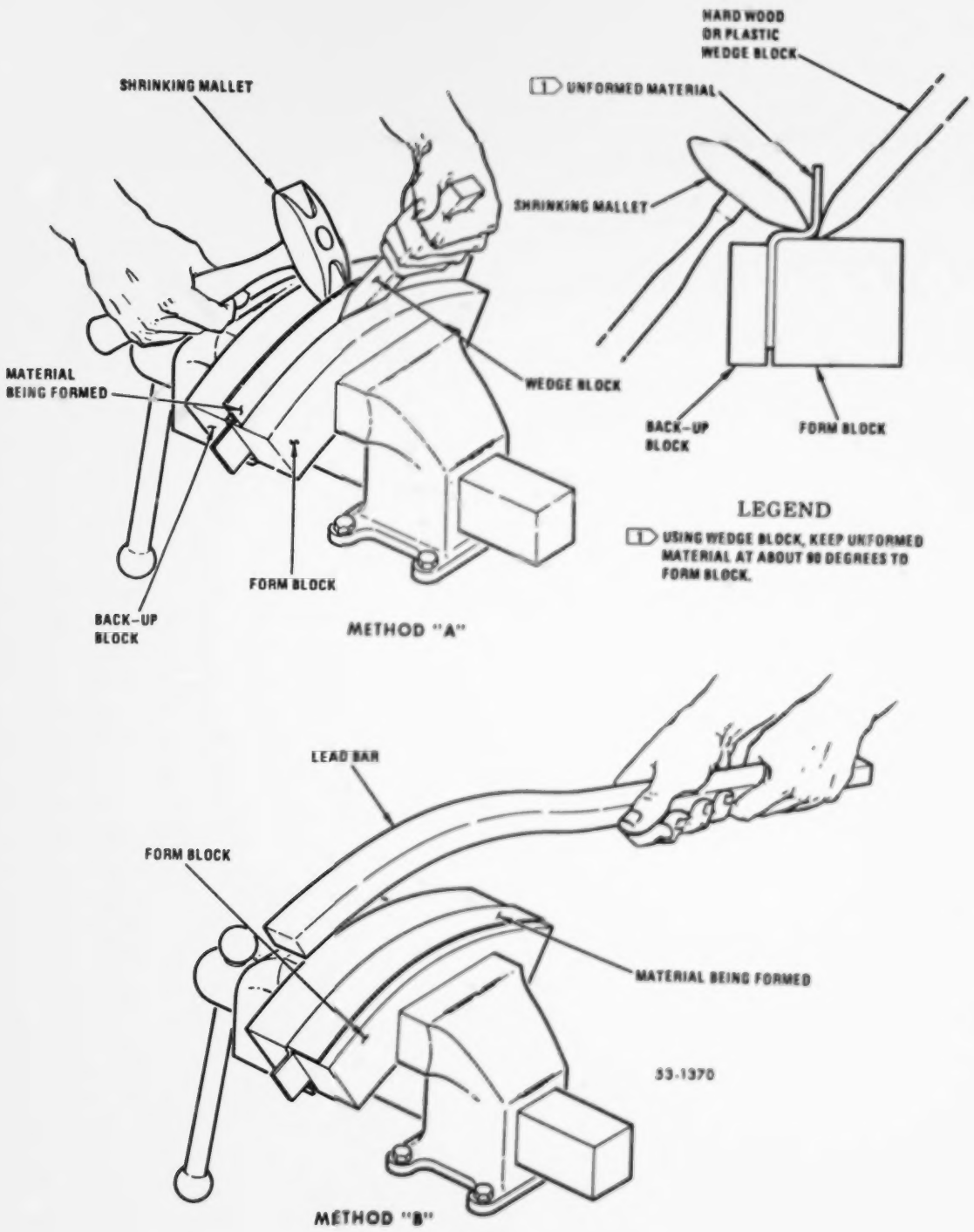


Figure 5-12. Hand forming convex surfaces.

8. What must you do to the metal to form convex flanges?

263. Differentiate between the two types of bumping processes.

Bumping. Bumping on a form block or female die and bumping on a sandbag are the two common methods. In either method only one form is required—a wooden block, lead die, or sandbag. A good example of a part made by the block or die type of bumping is the *blister* or streamlined cover plate. Wing fillets are a good example of parts that are usually formed by bumping on a sandbag.

Form block or die bumping. The lead die or the wooden block designed for bumping must have the same dimensions and contour as the outside of the blister. To provide sufficient bucking weight, and to give sufficient bearing surface for fastening the metal, the block or die should be at least 1 inch larger in all dimensions than the form requires.

When forming the wooden block, hollow it out with saws, chisels, gouges, files, and rasps. Smooth and finish it with sandpaper. Make the inside of the form as smooth as possible, because any slight irregularity will show up on the finished product. Prepare several templates (patterns of the cross section), such as those illustrated with the form block for the blister in figure 5-13, so that the form can be checked for accuracy.

Shape the contour of the form at points 2, 3, and 4. Shape the areas between the template checkpoints to conform to the remaining contour and to template 4. Shaping the form block requires particular care, because the more nearly accurate it is in all details, the less time it will take to produce a smooth finished part.

Keep in mind that it is important to clamp the material to the form block correctly. Several methods are possible. For parts such as the blister, one of the best means of clamping the material is to use a full metal cutout or steel holddown plate as shown in figure 5-13.

In this process, place the holddown plate directly over the material to be formed and clamp it in position with bolts or C-clamps. Tighten the C-clamps or bolts just tight enough to hold the material flat against the face of the form block, but not so tight that the metal cannot be drawn into the form. If the material is not held flat against the face of the form, it will bend up or buckle away from the block. If it is not permitted to slip into the concave depression a little, the blister portion will become very thin in places.

Holddown plates should be of heavy steel, ⅛ inch for small forms and ¼ inch or heavier for large forms. If the material for making a full metal holddown plate is not available, use a hardwood cutout. Make the cutout and use it in the same manner as the steel plate, but take greater precautions to make sure that the material is held as desired.

You may use pierced form clamps if a full metal holddown plate or hardwood cutout is not available or if a full cutout cannot be used. Be careful to clamp them properly and locate them so that they line up with the edge of the form. If they are not lined up properly and accurately, the material will bulge.

After preparing and checking the form, do the bumping as follows:

1. Cut a metal blank to size, allowing an extra ½ to 1 inch to permit *drawing*.
2. Apply a thin coat of light oil to the block and to the aluminum to prevent galling (scraping on rough spots).

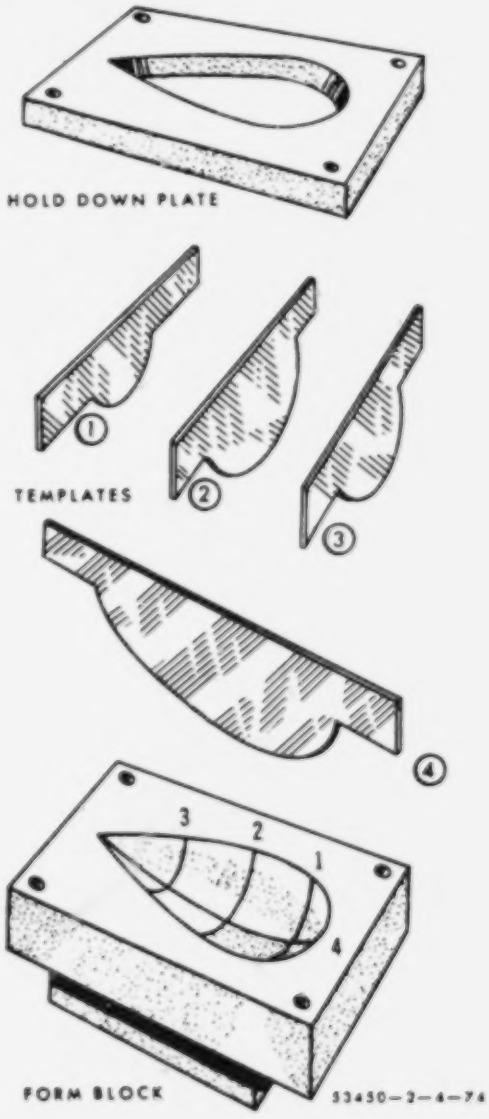


Figure 5-13. Form blocks and templates.

3. Clamp the material between the block and steel plate, as previously described, so that it will be firmly supported yet able to slip a little toward the inside of the form.

4. Clamp the bumping block in a bench vise. With a soft-faced mallet or with a hardwood-drive block and suitable mallet, start the bumping near the edges of the form.

5. With light blows of the mallet, work the material down gradually from the edges. Remember that the object of the bumping process is to work the material into shape by stretching it, rather than by forcing it into the form with heavy blows. Always start bumping near the edge of the form; never start near the center of the blister.

6. Before removing the work from the form, smooth it as much as possible by rubbing the work with the rounded end of a maple block or with the round end of a stretching mallet.

7. Remove the blister from the bumping block and trim it, leaving a ½-inch flange.

8. Finally, drill the rivet holes, chamfer the edges 45°, and clean and polish the part.

Sandbag bumping. Bumping on a sandbag is one of the most difficult types of sheet metal hand forming, because there is not an exact form block to serve as a guide. (See fig. 5-14.) During this type of forming operation, you force a depression into a sandbag to take the shape of the hammered portion of the metal. The depression or pit has a slight tendency to shift from the hammering, so you have to readjust the pit from time to time during the bumping process. The degree of shifting depends largely on the contour or shape of the piece being formed, and whether glancing blows must be struck in order to stretch, draw, or shrink the metal.

When forming by this method, prepare a contour template or some sort of pattern to serve as a working guide and to insure accuracy of the finished part. Make the pattern from ordinary kraft or similar paper, folding it over the part to be duplicated. Cut the paper cover at the points where it would have to be stretched to fit, and attach additional pieces of paper with masking tape to cover the exposed portions. After completely covering the part, trim the pattern to exact size.

Open the pattern and spread it out on the metal from which the part is to be formed. Although the pattern will not lie flat, it will give you a fairly accurate idea of the approximate shape of the metal to be cut, and the pieced-in sections will indicate where the metal is to be stretched. When the pattern has been placed on the material, trace the outline on the part with pencil and mark the portions to be stretched. Add at least 1 inch of excess metal when cutting the material to size. You can trim off this excess metal after bumping the part into shape.

If the part to be formed is radially symmetrical, a simple contour template can be used as a working guide. However, the procedure for bumping sheet metal parts on a sandbag follows certain basic rules which can be applied to any part, regardless of its contour or shape.

1. Lay out and cut the contour template. (This can be made of sheet metal, medium-heavy cardboard, or thin plywood.)

2. Determine the amount of metal needed, lay it out, and cut it to size, allowing at least ½-inch excess.

3. Place a sandbag on a solid foundation, capable of supporting heavy blows and with the aid of a smooth-faced mallet, make a pit in the bag. Analyze the part to determine the correct radius of the pit for the forming operation. (The pit will change with the hammering it receives and must be readjusted occasionally.)

4. Select a soft round-faced or bell-shaped mallet having a contour slightly smaller than the contour desired on the sheet metal part. Holding one edge of the metal in the left hand, place the portion to be bumped near the edge of the pit on the sandbag. Strike the metal with light glancing blows, about ½ to 1 inch from the edge.

5. Continue bumping toward the center, revolving the metal and working gradually inward until you get the desired shape. Shape the entire part as a unit. If you shape one portion completely and continue hammering on some other portion, the completed portion will be thrown out of shape.

6. At frequent intervals during the bumping process, check the part for accuracy of shape by applying the template. If wrinkles are formed, work them out before they become too large.

7. Finally, with a suitable stake and planishing hammer, or with a hand dolly and planishing hammer, remove the small dents and hammer marks.

8. With a pair of dividers, mark around the outside of the object. Trim the edge and file to a smooth finish. Clean and polish the part.

Exercises (263):

1. Which method of bumping does not use a fixed form?

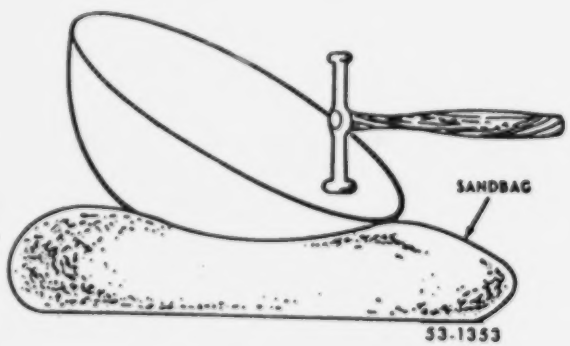


Figure 5-14. Sandbag bumping.

2. The finish dimension of a die used for bumping should be the same as what dimension of the part being formed?

3. Why is it required that the holddown plate, used during bumping, be just tight enough to hold the material flat against the face of the form block?

4. How much metal should you allow for drawing when forming by bumping dies?

5. Where should you start hammering when using die blocks?

6. What factor makes sandbag bumping more difficult than the die block method?

7. How do you determine the amount of metal necessary when sandbag bumping?

8. Where should you start hammering when forming using the sandbag method of bumping?

264. Describe methods and procedures used to form joggles.

Joggling. A joggle is an offset formed on an angle strip to allow clearance for a sheet or an extrusion. Joggles are often found at the intersection of formers and stringers. One of these members, usually the former, has the flange joggled to fit flush over the flange of the stringer. The amount of offset is usually small; therefore, the depth of the joggle is normally specified in thousandths of an inch. The thickness of the material to be cleared governs the depth of the joggle. In determining the length of the joggle necessary, it is common practice to allow an extra 1/16 inch to give enough added clearance to assure a fit between the joggled, overlapped part.

Methods. There are a number of different methods by which you can form joggles. If the joggle is to be made on a straight flange or flat piece of metal, form it on a cornice brake by inserting and bending up along the line of the joggle. Hold a piece of metal of the correct thickness to give the desired offset under the bent-up portion, and pound the flange down while the metal is still in the same position in the brake. Another method using the cornice brake is shown in the upper portion of figure 5-15. The joggle block method is clearly illustrated in the bottom of figure 5-15.

Joggling clips, such as the one shown in figure 5-16, can be used to form joggles on flanged angles. Follow the step-by-step procedures from the top in that flange, and notice especially the factors to consider in fabricating a joggle clip (gage, thickness, etc.)

Where a joggle is necessary on a curved flange, forming blocks or dies made of hardwood, steel, or aluminum alloy may be used. If the die is to be used only a few times, hardwood is satisfactory, as it is easily worked. If a number of similar joggles are to be produced, then use steel or aluminum alloy dies. Dies of aluminum alloy are preferred, since they are easier to fabricate than those of steel and wear about as long. They are sufficiently soft and resilient to permit forming aluminum alloy parts on them without marring; nicks and scratches are easily removed from their surfaces.

When using joggling dies for the first time, test them for accuracy on a piece of waste stock. In this way you avoid the possibility of ruining already fabricated parts. Always keep the surfaces of the blocks free from dirt, filings, and the like, so that the work will not be marred.

Exercises (264):

1. What method of forming joggles do you use when forming a joggle on a curved flange?

2. Explain the difference between the two methods of forming joggles using a cornice brake.

3. For metal dies, what type of material is preferred when forming joggles?

4. What determines the depth of joggles?

5. How can you avoid the possibility of ruining an already fabricated part when joggling?

6. How thick should a joggling clip be?

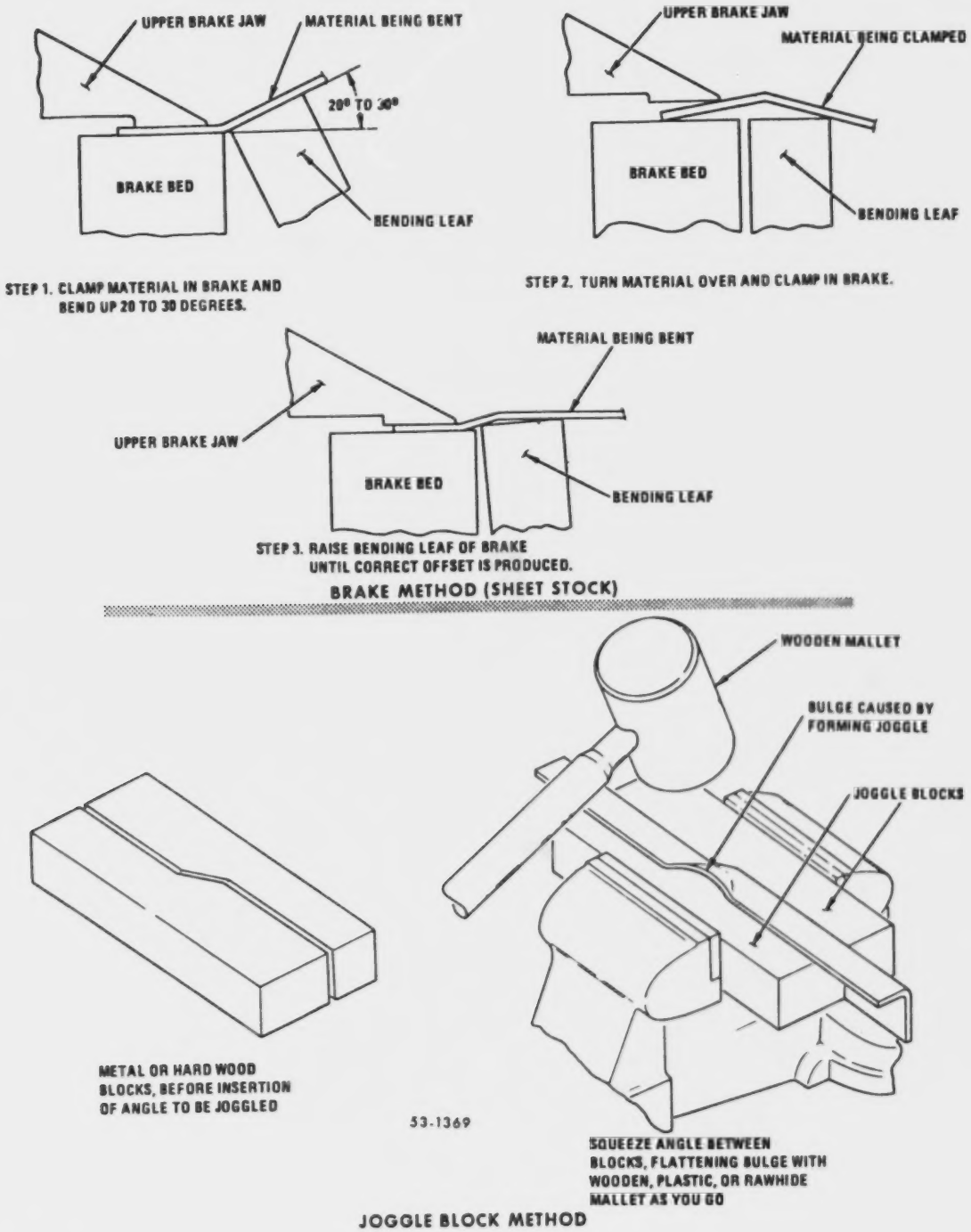

UPPER BRAKE JAW
MATERIAL BEING BENT
20° TO 30°
BRAKE BED
BENDING LEAF
STEP 1. CLAMP MATERIAL IN BRAKE AND BEND UP 20 TO 30 DEGREES.
UPPER BRAKE JAW
MATERIAL BEING CLAMPED
BRAKE BED
BENDING LEAF
STEP 2. TURN MATERIAL OVER AND CLAMP IN BRAKE.
MATERIAL BEING BENT
UPPER BRAKE JAW
BRAKE BED
BENDING LEAF
STEP 3. RAISE BENDING LEAF OF BRAKE UNTIL CORRECT OFFSET IS PRODUCED.
BRAKE METHOD (SHEET STOCK)
WOODEN MALLET
BULGE CAUSED BY FORMING JOGGLE
JOGGLE BLOCKS
METAL OR HARD WOOD BLOCKS, BEFORE INSERTION OF ANGLE TO BE JOGGLED
53-1369
SQUEEZE ANGLE BETWEEN BLOCKS, FLATTENING BULGE WITH WOODEN, PLASTIC, OR RAWHIDE MALLET AS YOU GO
JOGGLE BLOCK METHOD

Figure 5-15. Forming joggles using brake or joggle blocks.

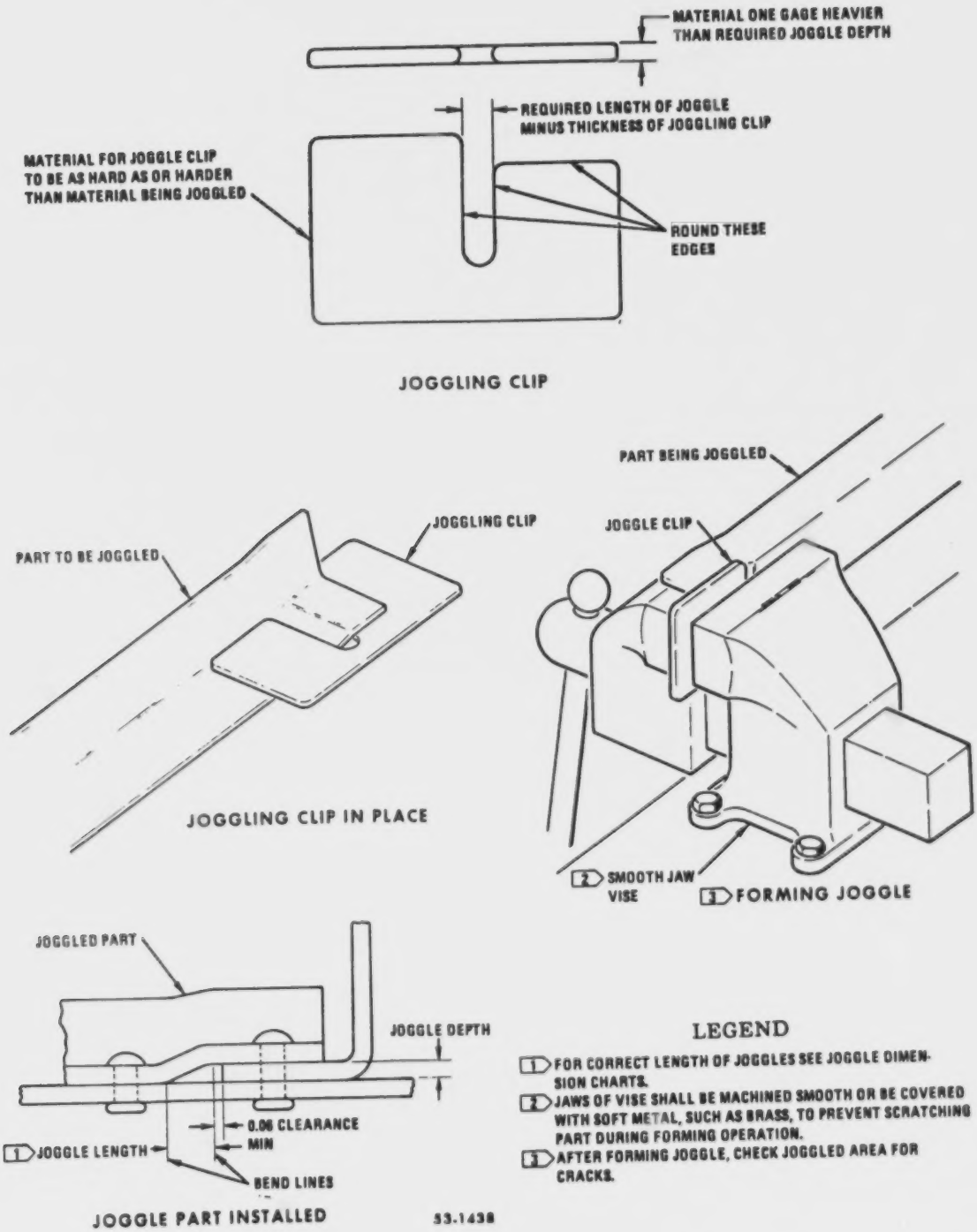

MATERIAL ONE GAGE HEAVIER THAN REQUIRED JOGGLE DEPTH
REQUIRED LENGTH OF JOGGLE MINUS THICKNESS OF JOGGLING CLIP
MATERIAL FOR JOGGLE CLIP TO BE AS HARD AS OR HARDER THAN MATERIAL BEING JOGGLED
ROUND THESE EDGES
JOGGLING CLIP
PART TO BE JOGGLED
JOGGLING CLIP
JOGGLING CLIP IN PLACE
PART BEING JOGGLED
JOGGLE CLIP
2 SMOOTH JAW VISE
3 FORMING JOGGLE
JOGGLED PART
JOGGLE DEPTH
0.06 CLEARANCE MIN
1 JOGGLE LENGTH
BEND LINES
JOGGLE PART INSTALLED
53.1438
LEGEND
1 FOR CORRECT LENGTH OF JOGGLES SEE JOGGLE DIMENSION CHARTS.
2 JAWS OF VISE SHALL BE MACHINED SMOOTH OR BE COVERED WITH SOFT METAL, SUCH AS BRASS, TO PREVENT SCRATCHING PART DURING FORMING OPERATION.
3 AFTER FORMING JOGGLE, CHECK JOGGLED AREA FOR CRACKS.

Figure 3-16. Forming joggles using joggling clips.

7. What determines the width of the slot on the joggling clip?

8. What device is used to form the joggle when using a joggling clip?

5-2. Machine Forming

The machines that we cover are the ones usually found in most airframe repair shops. Many of these machines are similar, and you decide which to use by the size and shape of the part to be formed. With only slight variation, many jobs can be done on the same machine, to avoid changing from one to another when forming or folding metal.

265. Describe specific adjustments and procedures for the use of a bar folder, cornice brake, and box and pan brake.

Bar Folder. The bar folder shown in figure 5-17 is designed for use in making bends or folds along edges of sheets of metal. This machine is best suited for folding small hems, flanges, seams, and edges to be wired. Most bar folders have a capacity for metal up to 22 gage in thickness and 42 inches in length. Before using the bar folder you must make several adjustments, including adjustments for thickness of material, width of fold, sharpness of fold, and angle of fold.

Thickness of material. The adjustment for thickness of material is made by adjusting the screws at each end of the folder. As this adjustment is made, place a piece of metal of the desired thickness in the folder and raise the operating handle until the small roller rests on the cam. Hold the folding blade in this position and adjust the setscrews so the metal is clamped securely and evenly the full length of the folding blade. After the folder has been adjusted, test each end of the machine separately with a small piece of metal by actually folding it.

Be extremely careful not to overadjust the bar folder so that the clamping pressure is too great, because such an adjustment will damage the clamping blade. This condition is easy to avoid if you just make sure the machine operates freely. If it does not operate freely, the clamping blade is too tight.

Width of fold. The width of fold is controlled by the adjusting screws shown in the inset view of figure 5-17. The gage adjusting screw moves the slide and gage back and forth for the width of the desired fold. The gage is graduated in fractions of an inch from 0 to 1 inch, since a 1-inch fold is the largest that can be made on this folder. After the adjustment is made, lock the gage in place by tightening the lockscrew which is located on the right side of the gage. If it is necessary to fold greater than 1 inch, use the cornice brake.

Sharpness of fold. The bar folder can be used for making either sharp or round folds. The sharpness of the fold is controlled by raising or lowering the wing. This requires the proper adjustment of the wedge which supports the wing. The wedge adjusting knob is located in the center of the folding blade. Before the wedge adjustment can be made, the wing must be perpendicular to the folding blade. To make a sharp fold, set the wedge so that the wing stays in the same position through a cycle of operation. To make a round fold, adjust the wedge so that the wing is forced back when you make your fold.

Angle of fold. There are two positive stops on the folder, one for 45° folds or bends and the other for 90° folds or bends. An additional feature (a collar) is provided and can be adjusted to any degree of bend within the capacity of the machine. For forming angles of 45° or 90°, move the correct stop into place. This allows you to move the handle forward to the correct angle. For forming other angles, use the adjustable collar (shown in the inset of figure 5-17) by loosening the setscrew and setting the stop at the desired angle. After setting the stop, tighten the setscrew and complete the bend.

Making the fold. To make the fold, adjust the machine correctly, using the procedures given above, and then insert the metal. The metal goes between the folding blade and jaw. Hold the metal firmly against the gage as you pull the operating handle toward you. As the handle is brought forward, the jaw automatically raises and holds the metal until the desired fold is made. When the handle is returned to its original

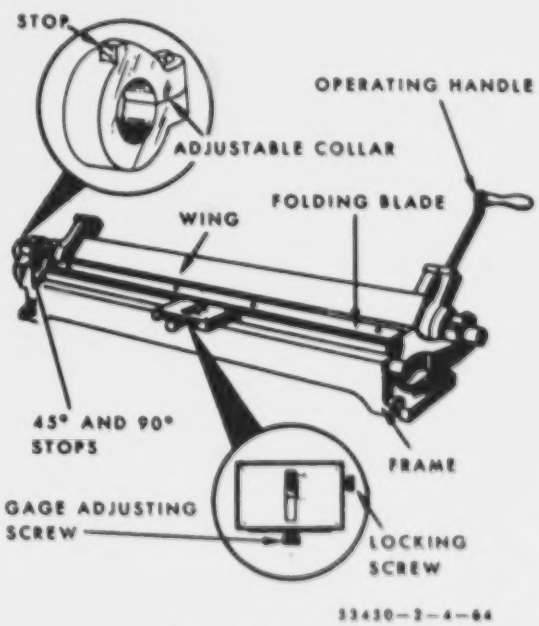


Figure 5-17. Bar folder.

position, the jaw and blade return to their original positions and release the metal.

Cornice Brake. The cornice brake (fig. 5-18) has a much greater range of usefulness than the bar folder. The bar folder can form a bend or edge only as wide as the depth of the jaws. In comparison, the cornice brake allows the sheet to pass through the jaws from front to rear without obstruction.

When you make ordinary bends with the cornice brake, place the sheet on the bed with the sight line (mark indicating line of bend) directly under the edge of the clamping bar, as shown in figure 5-19. Then bring the clamping bar down to hold the sheet firmly in place. Set the stop at the right side of the brake for the proper angle or amount of bend and raise the bending leaf until it strikes the stop. If other bends are to be made, lift the clamping bar and move the sheet to the correct position for bending.

When bending sheets heavier than 22 gage, raise the clamping bar an amount equal to the thickness of the metal and set it back the same distance. When bending sheets heavier than 22 gage, reinforce the bending leaf with angle iron.

The bending capacity of a cornice brake is determined by the manufacturer, and depends on the bending edge thickness of the various bending leaf bars. Standard capacities of this machine are from 22- to 12-gage sheet metal, and bending lengths are from 3 to 12 feet.

Most metals have a tendency to return to their normal shape, a characteristic known as springback. If you set your cornice brake for a 90° bend, the metal bent will probably form an angle of about 87° to 88°. Therefore, if a bend of 90° is desired, you should set your cornice brake to bend an angle of about 93° to allow for springback.

There are also occasions when you find the material bends excessively, or bends further on one side of the brake than on the other. To correct this condition, set the top leaf back on the end where the sheet is overbending.

Adjustment of brake. To get the most out of a brake, you have to know how to adjust it for various operations. These adjustments are very important; they save time and improve the quality of your work.

To begin with, the cornice brake must be level on the floor. If the cornice brake is not level, the top leaf will creep when clamping metal between jaws. If the top leaf does creep, adjust setscrew H and capscrew B shown in figure 5-18. If this does not remedy the creeping, place a wedge of wood or similar material under the rear leg on the side that creeps. After the creeping is eliminated, replace the wedge with a permanent block of the proper thickness.

Check the bending leaf when it is in the DOWN position. The edge of this leaf should be $\frac{1}{64}$ inch below the bed edge of the ends and $\frac{1}{32}$ inch below the bed edge at the center. To obtain and maintain this alignment:

- Adjust leaf ends with screws D.
- Adjust leaf center with bolt E.
- Adjust bed ends with screws F.
- Adjust bed ends with bolt G.

To adjust for bending various thicknesses of sheet metal stock with the cornice brake, move the upper nose bar back at the bending edge. If the material to be bent is within 4 gages of the capacity of the machine, move the top leaf back twice the thickness of the material.

When sharp bends are to be made on lightweight metal, move the top leaf forward. To adjust the top leaf, loosen screws B (fig. 5-18) and move the top leaf forward or backward by adjusting screws A or H. (These screws have right-hand threads.) Once the correct adjustment is made, lock the adjustment with screws B.

The clamping pressure should be tight enough to hold the metal in place while the bend is being made. Different gages of metal require different adjustments, so you must realize that every gage of metal will have its own adjustment. Remember, the pressure should be equal on both ends of the machine. This clamping pressure can be changed by adjusting the link blocks J. To adjust the link blocks, loosen screws R, and then loosen screws K which hold link adjustment blocks J. Adjust the blocks to thickness of metal with screws L, and lock the adjustment with screws K. Check by using a test strip to be sure that the machine is correctly adjusted. If it's not right, repeat the adjustment procedures.

If the bend leaf becomes bowed after heavy use, tighten both bolts Z until the center is brought into line. This line should be a straight line; check it with a straightedge.

Formers. Molds or formers can be obtained in half-round sizes such as ⅜, 1, 1⅜, 2¼, and 3 inches. They are used most often to make gutters. These formats are attached to the cornice brake by means of clamps. When attaching the formers to the brake, leave ½-inch clearance on the side of the formers against the bending leaf. Position the clamps vertically to the ground and tap lightly with a mallet. This creates enough friction to hold the formers in place. To remove the clamps, tap upward with a mallet.

Box and Pan Brake. The construction of the box and pan brake is a great deal like that of a cornice brake except that the clamping leaf is divided into sections called fingers or shoes. These fingers vary in width and are all interchangeable. This machine, illustrated in figure 5-20, is especially designed for making boxes of various sizes and shapes; it permits the forming of all sides without distorting any of the finished bends. If necessary, this brake can be used to do any work that can be done on a standard cornice brake.

If the brake needs adjustment, since it is a great deal like the cornice brake, all adjustments (such as radius and thickness) can be made by the same procedures as with the cornice brake. The steel fingers are secured to the upper beam by means of thumbscrews. The fingers must be securely seated and the thumbscrews

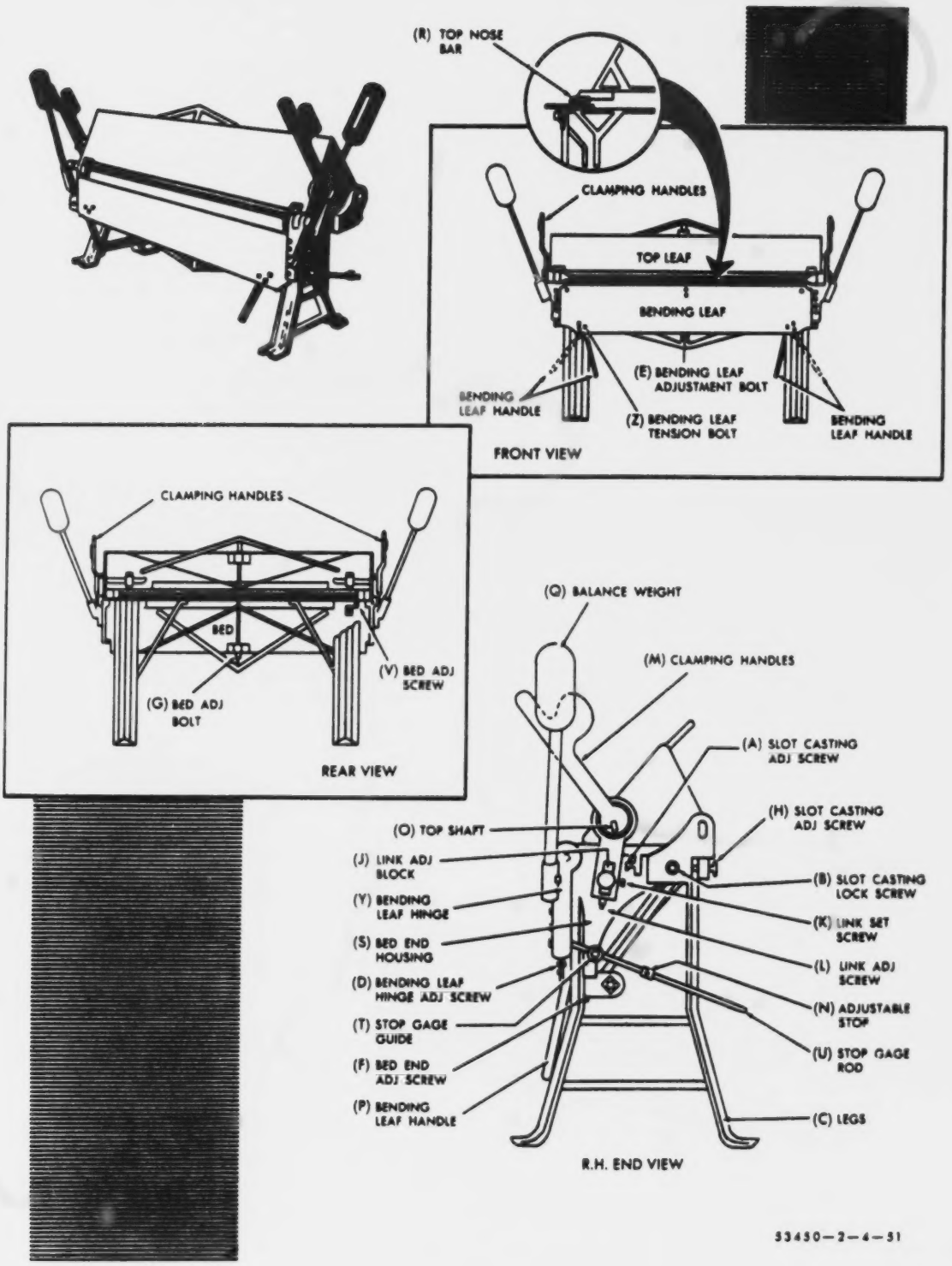


Figure 5-18. Cornice brake.

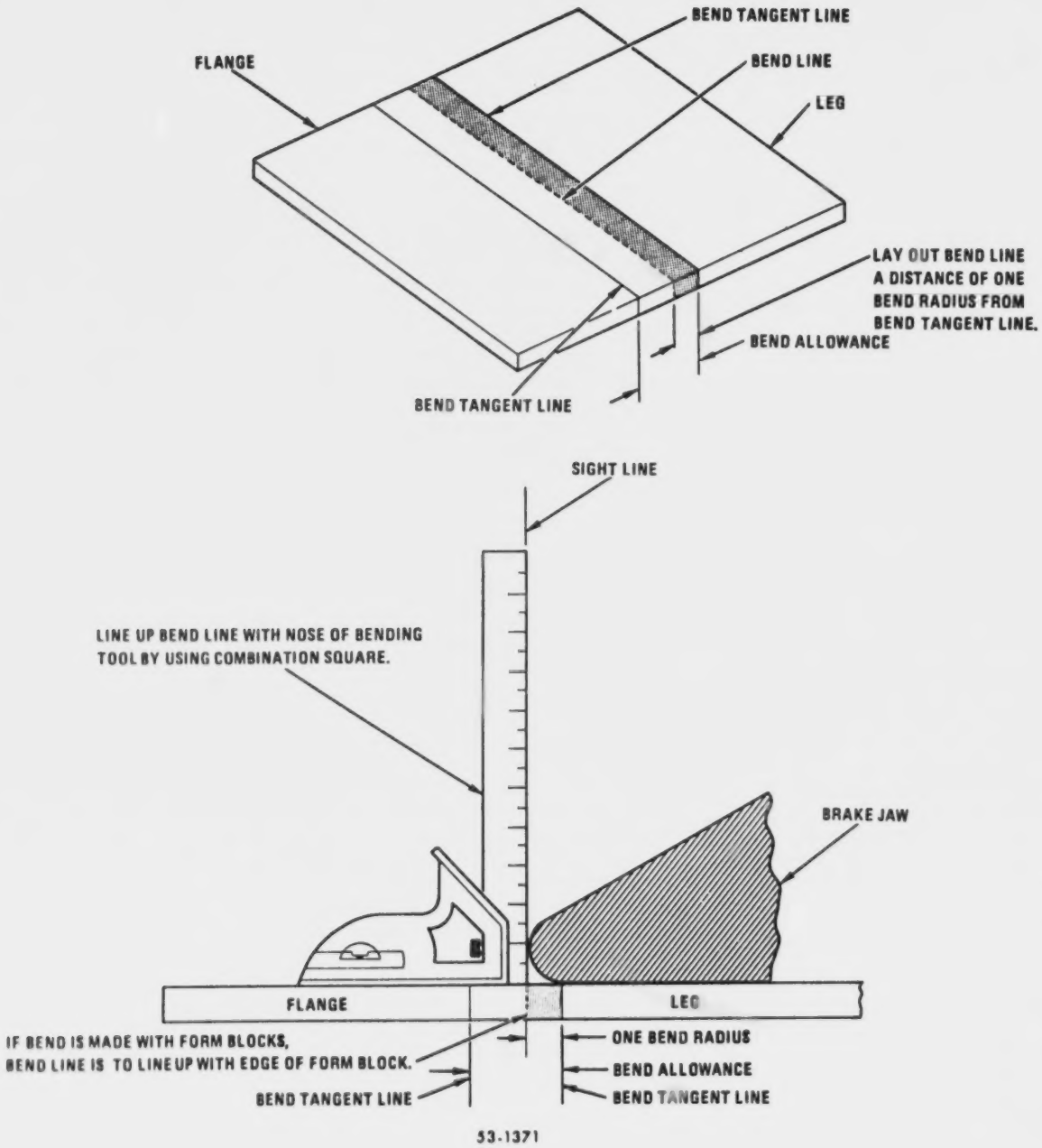


Figure 5-19. Use of bend lines—cornice brake.

tightened before using the brake. To remove any of the fingers, simply loosen the thumbscrews, raise the clamping fingers by pushing the clamping bar backward, and then pull the finger forward. When installing the fingers, reverse this procedure.

Before you start any work on the box and pan brake, be sure all the adjustments are made for the gage of metal you are using. Do not bend rod, wire, band iron, or spring-tempered sheets on either the box and pan or cornice brakes.

Exercises (265):

1. What adjustments must be made before using a bar folder?

2. What is the largest depth of flange that you can make on a bar folder?

3. What do you do to apply pressure to metal being formed with a bar folder?

4. What is the largest flange (depth) that you can form on a cornice brake?

5. How many degrees must you add on to allow for springback when using a cornice brake?

6. What factor determines the adjustments on the cornice and box and pan brake?

7. If the bending leaf on a cornice brake is properly adjusted, what should be the clearances at the center and ends?

8. How can you check to insure that the bending leaf is not bowed?

9. How does a box and pan brake differ from a cornice brake?

10. What advantage has a box and pan brake over a cornice brake?

266. Describe adjustment procedures and analyze given substandard results obtained when using a powered or manually operated slip roll former.

Hand-Operated Slip Roll Forming Machine. The slip roll forming machine, illustrated in figure 5-21, is used to form sheets into cylinders of various diameters and to form permanent curves in flat sheet stock. The machine is simply constructed and consists of right- and left-end frames (housings) between which are mounted three solid steel rolls—two lower rolls and one upper roll. The two lower rolls are connected by gears operated by a handcrank. The lower front roll can be adjusted to the thickness of the metal by means of two knurled adjusting screws (one at each end of the roll). Once the metal is started into the machine, it is gripped between the lower front roll and the upper roll and is carried to the lower rear roll which bends it around the upper roll, thus forming a cylinder. If the adjusting screws at each end of the lower rear roll are turned to the right, a smaller radius will be produced; if the screws are turned to the left, a larger radius will be produced. (See fig. 5-21.)

On most hand-operated slip roll forming machines, the upper roll can be released at one end, which permits a formed cylinder to be removed from the machine without distortion. The rolls are grooved on one end for forming wire and wired edges. The capacity of slip roll forming machines is determined by the manufacturer and must not be exceeded.

Proper slip roll operation requires a number of adjustments. The lower front roll must be adjusted so that it and the upper roll have a uniform grip on the metal. Once this adjustment has been made, the metal should ride smoothly through the rolls. In making a preliminary test it is best to select a piece of scrap material of the same gage as the metal you plan to form. Crank the test piece through the gripping rolls until it comes in contact with the lower rear roll. Then by means of the adjusting screws, set the lower rear roll for the desired radius. This adjustment must be the same on both ends to form cylinders unless a taper is desired. A truncated cone (or frustum) is formed when the screws have different adjustments. When the rolling process is completed, release and raise the upper roll. Then remove the test piece and make final adjustments. Place the material square with the rolls, and turn the crank clockwise. The cylinder that is formed should be the finished product. No change of adjustments on the machine are necessary if more than one item of the same size is to be formed.

Power-Operated Slip Roll Forming Machine. The power-operated slip roll forming machine, shown in figure 5-22, is a great deal like the hand-operated slip roll machine in that it has two lower rolls and one

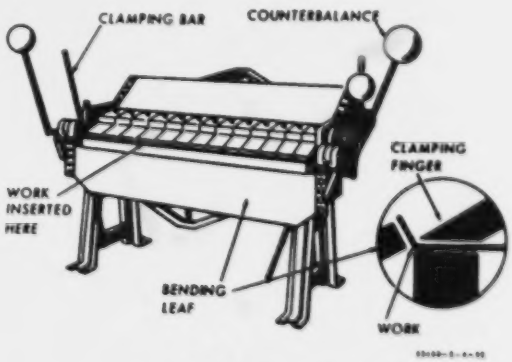
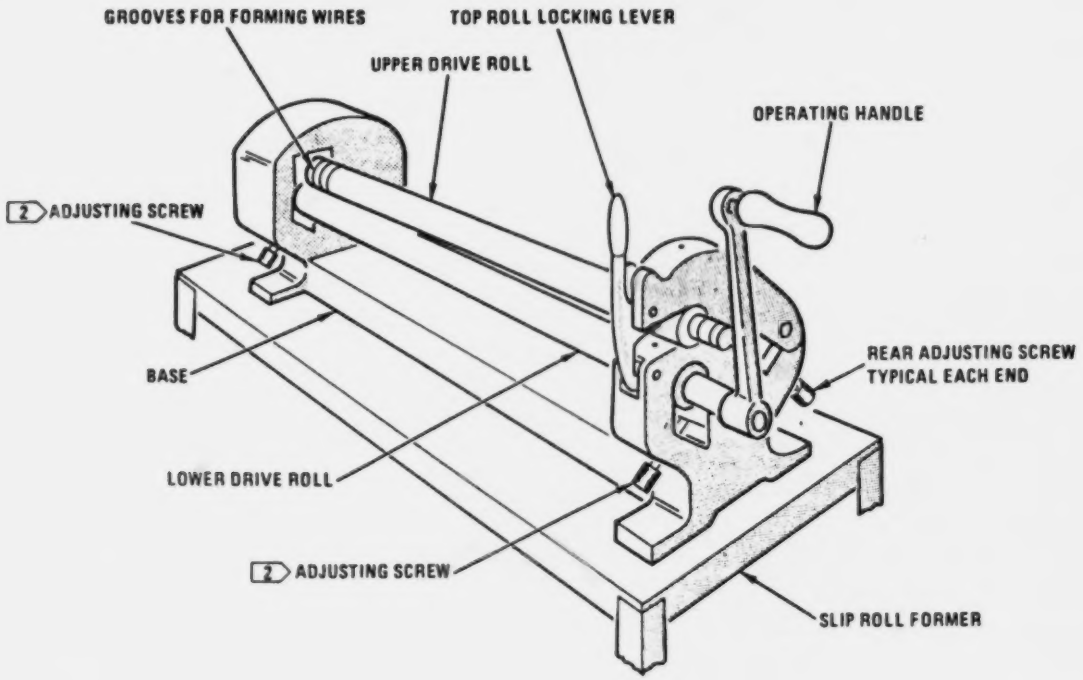
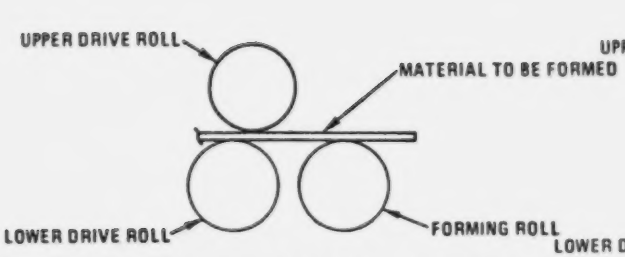
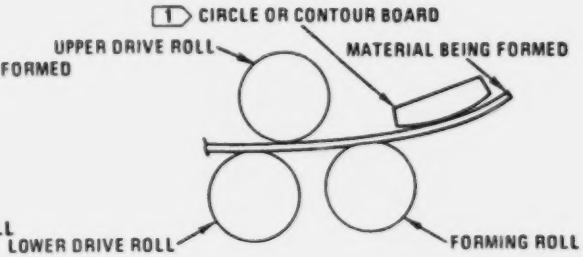


Figure 5-20. Box and pan brake.

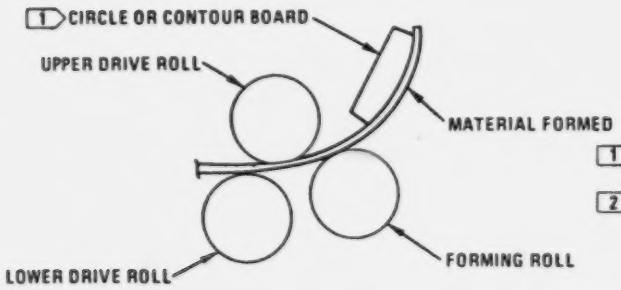




STEP 1. ADJUST THE ROLL AND INSERT MATERIAL TO BE FORMED.



STEP 2. TURN REAR ADJUSTING SCREWS TO RAISE THE FORMING ROLL AND PASS THE MATERIAL THROUGH THE ROLL.



STEP 3. READJUST FORMING ROLL TO GIVE REQUIRED CURVE AND PASS MATERIAL THROUGH THE ROLLS.

LEGEND

1 CIRCLE OR CONTOUR BOARD SHOULD HAVE RADIUS EQUAL TO REQUIRED RADIUS OF FORMED PART.

2 TAPERED SHAPES CAN BE FORMED BY TIGHTENING ADJUSTING SCREW ON ONE END OF ROLLS AND LOOSENING SCREW ON OTHER END.

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Figure 5-21. Slip roll operation.

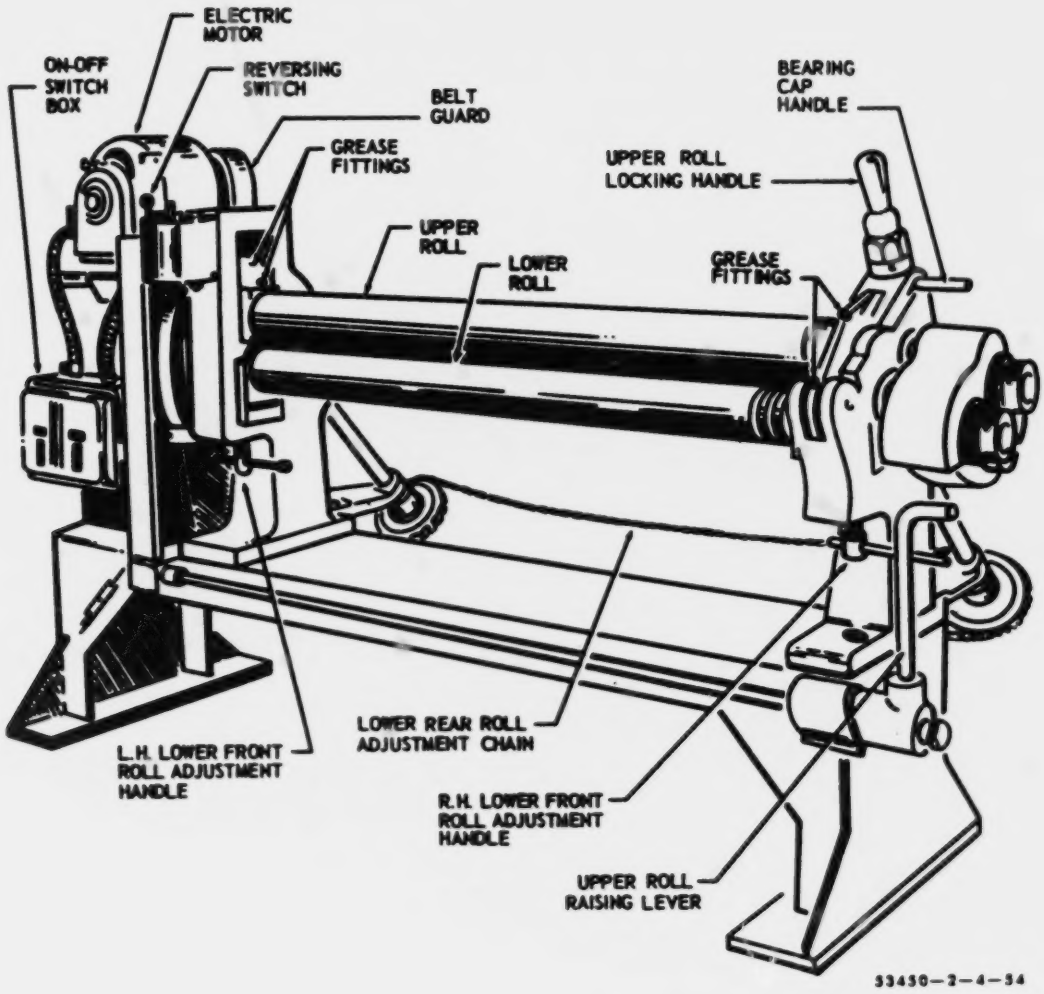

Figure 5-22. Power-operated slip roll forming machine.

upper roll. However, turning power for the rolls is supplied by an electric motor. Direction of the rolls is controlled with a reversing switch.

The power-operated slip roll machine, like the hand-operated version, has a limitation as to the diameter (radius) it can produce. When the machine is operating at maximum capacity (thickness and size of the sheet stock), the diameter of the cylinder formed should not be less than two times the diameter of the upper roll. If this recommendation is not followed, the formed cylinder will have flat spots at the seam.

The front gripping rolls can be adjusted for clearance (according to the thickness of metal to be formed) by turning screw handles located under the ends of the lower front roll. The lower rear roll can be adjusted for radius of bend by moving the endless chain. This chain turns adjustment screws at each end of the machine to keep the lower rear roll parallel with the gripping rolls. After the cylinder is formed, it can be removed by releasing the upper roll locking handle and pressing down on the raising lever located at the right end of the machine.

Before starting the electric motor, press the ON button of the ON-OFF switch. Then move the directional switch lever from the OFF position to the FORWARD position. This starts the motor and sets the rolls in motion for normal operation. When it is necessary to reverse the direction of the rolls, move the direction switch lever to the OFF position until the rolls stop rotating; then move the lever to the REVERSE position. When a job has been completed, stop the rolls and remove power by moving the direction switch lever to the OFF position and by pressing the OFF button of the ON-OFF switch.

Operation of the power-operated slip roll machine is similar to that of the smaller, hand-operated slip roll except that heavier gage metal can be formed. The heavier gages must be inserted and rolled for 7 to 9

inches, then backed out, turned around, and rolled from the other end in the regular way. This is done to prevent a flat spot along the seam.

Maintenance is about the same for hand-operated and power slip roll machines—lubricating the moving parts, keeping the rollers clean, and keeping the machines clear at all times. When the rollers get dirty, clean them with steel wool and a dry rag; then wipe them with an oiled rag to prevent corrosion.

You should observe safety precautions, such as keeping your hands, fingers, and clothing clear of the rollers and drive gears, at all times. As with other machines, handle metal carefully to keep burrs from cutting your hands. Never apply power to the rolls until you are certain the machine is clear. If you are working on large jobs that require assistance from another worker, make certain that you both are qualified operators and that you understand which part of the operation each will perform.

Exercises (266):

1. To decrease the radius of forming, which roller of the slip roll former is moved and in what direction?

2. What shapes may be formed with the slip roll former?

3. If a cylinder is overformed on one end and underformed on the other, what mistake was made in using a hand-operated slip roll former?

4. With the rollers adjusted correctly, what mistake was made, when using the power-operated slip roll former to form ⅛-inch aluminum into a cylinder, if all but the last 4 inches have the correct radius?

5. If a slip roll forming machine has been used to form block iron and a coating of rust inhibitor has come off on the rollers, what should be done to the rollers?

267. Describe the setup and operating principles of the powered flanging machine.

Powered Flanging Machine. The powered flanging machine illustrated in figure 5-23, produces flanges on the edges of sheet metal. Both straight and curved flanges can be produced on this machine. Flanges can be formed on the outside edge of a circle or on the inside edge of a circle that has a radius of 6 inches or larger. The powered flanging machine can accommodate sheet metal as thick and as strong as .135 gage mild steel.

Principles of Operation. Although this machine consists of many internal parts that make it operate properly, only three of these parts are of prime interest to you. These three parts are shown in figure 5-24. The holddown tool (fig. 5-24) is made with two curved finger-like extensions at the rear of the tool. These extensions act as a stop. By holding the metal firmly against these fingers you can make a flange of uniform width for the entire length of the metal. Holddown tools and brakehead tools are available in various sizes. Each matching pair is specifically made for a particular flange height, bend radius, and metal thickness.

To produce flanges of different sizes you must change both the holddown tool and the brakehead tool. These tools are identified with code numbers which are stamped on the tools. Figure 5-25 shows a breakdown of the numbering system which allows you to identify the pair of tools needed for a particular use.

The first number represents the design number; the second number is the flange height, measured in 64ths of an inch; the third number is bend radius measured in 64ths of an inch; and the fourth number is the range of metal thickness measured in 100ths of an inch. For flanges having angles other than 90°, a fifth number indicates the angle in degrees.

When the machine is operated, the holddown tool and the brakehead tool work together as a team. The holddown tool presses down on the metal, holding it firmly against the anvil. Then, the brakehead tool swivels up and forms a small portion of the flange. As the brakehead begins to return to its original position, the holddown tool rises and allows the operator to slide the metal a little. This action is repeated many times to make a small flange.

Smooth, well formed flanges are produced by passing the edge of the metal between the holddown and brakehead tools several times. The first pass is made with the machine set to produce only a small degree of bend. On each successive pass the brake tool is adjusted to produce a greater degree of bend, until the desired flange is formed.

As stated above, the degree of bend is adjustable (up to 90°). This adjustment is made by turning the brake-stroke wheel at the front of the machine.

The number of passes required to complete a 90° flange varies with the thickness, kind of metal, flange height, and the curve radius of the edge of the sheet. Since all of these factors are involved, it is not possible to give complete information to cover all situations. Normally, however, four passes are required to make a smooth 90° angle flange.

Operational Sequence. In preparing to use the machine, determine the size, type of flange, and the

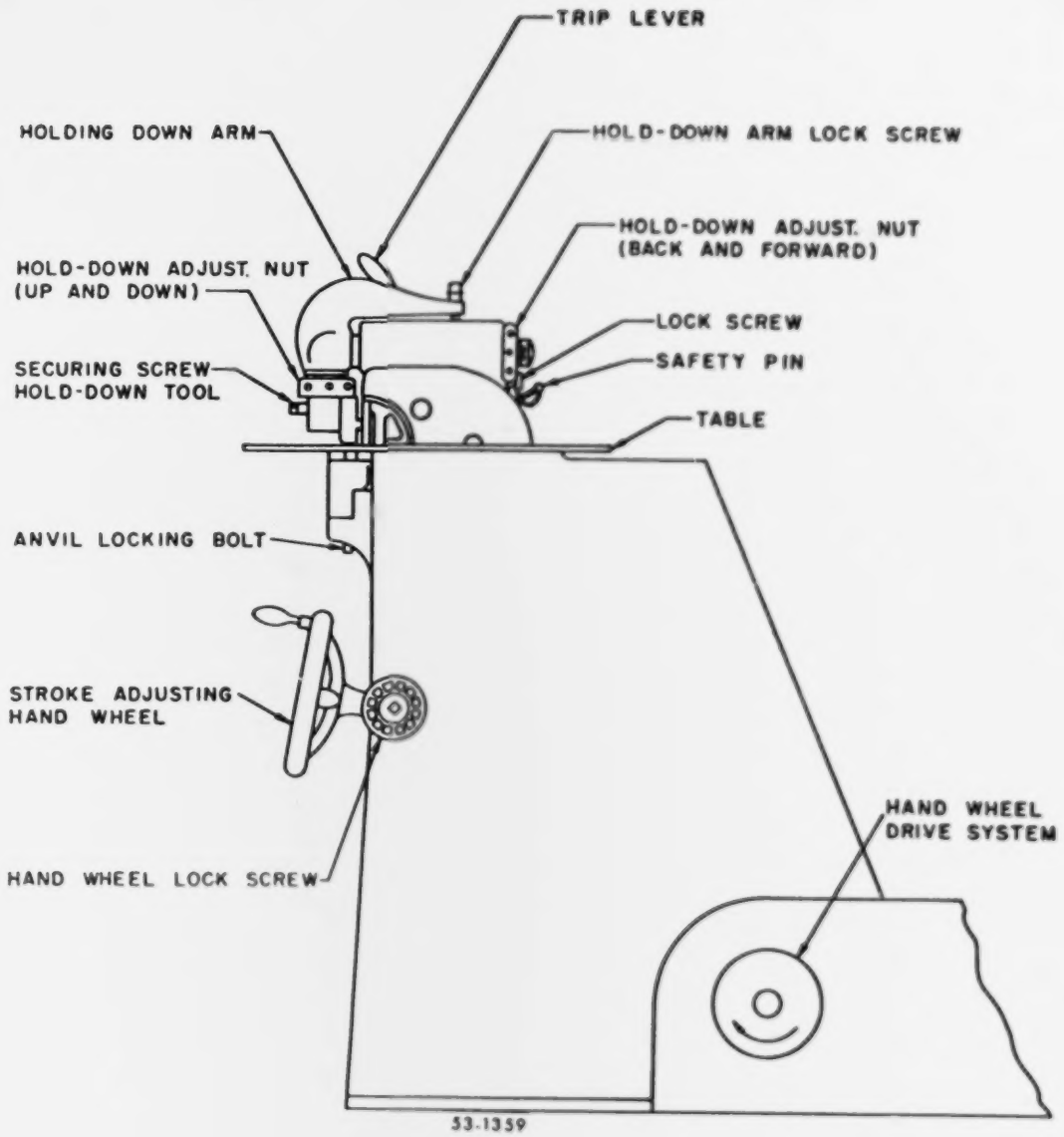

Figure 5-23. Powered flanging machine.

gage of repair material; select the correct holddown tool, brake tool, and spacers for the flange to be formed; raise the brakehead by pushing the trip lever backwards; and install the spacers, brake tool, and holddown tool.

Lower the brakehead by pulling the trip handle lever forward, move the flywheel so that the brakehead is in the lowest position, and adjust the holddown tool for the thickness of metal being formed. Place the metal between the holddown tool and the table. Make the correction for thickness with the vertical adjustment.

Remove the metal and turn the handwheel so that the brake tool will be in the vertical position, and then adjust the clearance for the flanges by using the horizontal adjustment. Check the adjustments to see that the parts are not binding. Turn the flywheel by hand.

Use the handwheel to lower the brake tool to the lowest position, and then raise the brakehead and insert the metal under the holddown tool. The edge of the metal should touch the finger guide. Oil may be used to lubricate the metal for ease in movement.

Finally, lower the brakehead with the trip lever and revolve the flywheel to check the machine.

The preparation is actually the hard part. Once you finish preparations, start the machine at a slow speed and turn the handwheel until the brake tool bends the

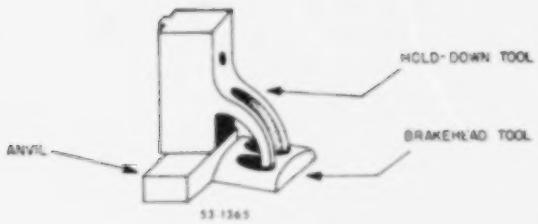

Figure 5-24. Flanging machine—main parts.

flange approximately 30°. Slowly move the metal back and forth under the holddown tool, keeping the contoured edge against the finger guide until the entire flange starts forming.

CAUTION: Keep your fingers away from the holddown and brake tools while the machine is operating.

After the flange is bent approximately 60°, stop the machine and change to a higher speed if you desire. When the flange is formed, lower the brake tool to the lowest position and stop the machine. Raise the brakehead and remove the work.

Exercises (267):

1. What four factors must be considered in selecting the proper forming dies to use with a power flanging machine?

2. Describe the operational sequence of the holddown and brakehead tools of the power flanging machine.

3. Normally, how many passes are required to produce a smooth, well formed flange with a power flanging machine?

4. What factor determines the adjustments on a power flanging machine?

5. When is the power flanging machine changed to a higher speed setting?

268. Specify the results of a given procedure or the procedure to cause a specified result when using a stretching and shrinking machine.

Stretching and Shrinking Machine. The stretching and shrinking machine (fig. 5-26) is used to produce concave and convex flanges from simple L shaped angles. This machine can be equipped with either stretching or shrinking jaws. A simple interchange of the jaw assemblies on this machine allows it to be converted from a shrinking machine to a stretching machine. The machine is operated by a footlever that is swung back and forth. When the machine is not being used, the footlever can be locked in the back position to prevent tripping accidents. To lock the footlever in the rear position, push the footlever all the way back and hold it there, then pull the footlever retaining lock handle forward. While holding the lock handle forward, slowly release the footlever until it stops. When the machine is to be used again, the footlever can be unlocked by simply pushing it back and then allowing it to swing forward.

Assume that shrinking jaws are installed. When the footpedal is swung back and forth, the upper jaws move downward. As they grip the metal, they are forced together. This action pushes the metal together, shrinking the flange.

If stretching jaws are installed in the machine, the jaws *separate* as they come down and grip the metal. This action stretches the metal. Figure 5-27 illustrates the movement for both jaws.

The handwheel located at the top of the machine is used to adjust the space between the upper and lower jaws. This adjustment compensates for different gages of metal and provides proper gripping pressure for all thicknesses.

To adjust the machine for a specific thickness of sheet metal use these procedures: (1) depress the footlever until it is all the way back, (2) turn the handwheel at the top of the machine until the opening between the upper and lower jaws is wide enough to insert the metal, (3) insert the metal, (4) still holding the footlever back turn the handwheel until the jaws are snug against the metal, (5) release the footlever and turn the handwheel one-quarter turn tighter. These procedures should adjust the machine precisely for the gage of metal you are working with. When shrinking, there

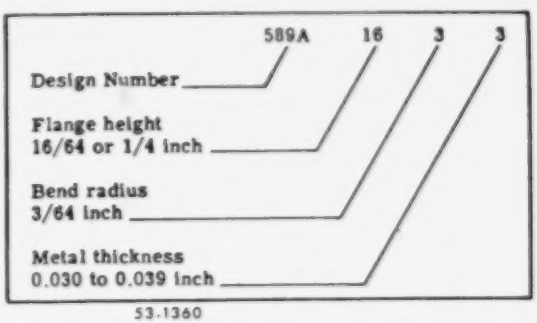

Figure 5-25. Identification coding—forming dies.

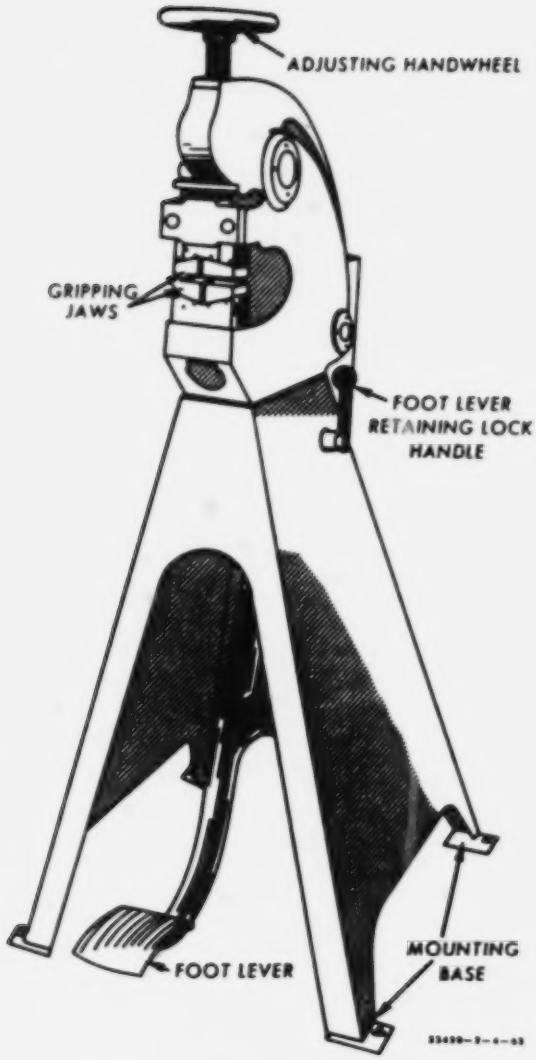

Figure 5-26. Stretching and shrinking machine.

should be a ¼-inch space between the standing flange and the jaws. When stretching only a slight space is needed between the standing flange and the jaws.

Operating Procedures. To stretch a flange, a series of local upsets or elongated areas must be formed; therefore, do not apply repeated strokes to one spot, because this will cause splitting or cracking of the flange. For most effective working, enter the workpiece to about the centerline of the jaws, and feed the work through the machine in equal distances for each stroke of the jaws.

To insure proper operation of the jaws, they must be kept clean of excessive amounts of grease and metal which will adhere to the gripping portion of the jaws, especially clad material. Light oil or kerosene on the workpiece of metal has the tendency to pump the metal particles out of the jaws' surfaces. Periodically remove the jaws and jaw blocks from the machine, disassemble them, and clean them of grease and metal deposits. After cleaning, reassemble the parts and grease them prior to reinstallation on the machines.

Exercises (268):

1. What happens to the flange when the movements of the jaws on a shrinking and stretching machine move inward?

2. What direction do the jaws move on a shrinking and stretching machine when stretching metal?

3. Splitting or cracking of the flange being formed is usually the result of overlooking what procedure?

4. Describe the procedures for feeding the work in order to insure effective forming when using a shrinking and stretching machine.

5. What should you do to insure proper movement of the forming jaws?

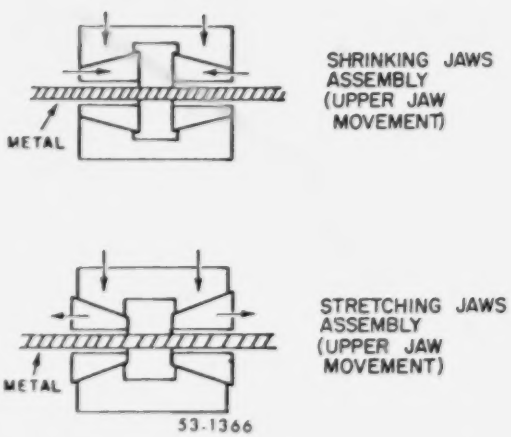

Figure 5-27. Jaw movements.

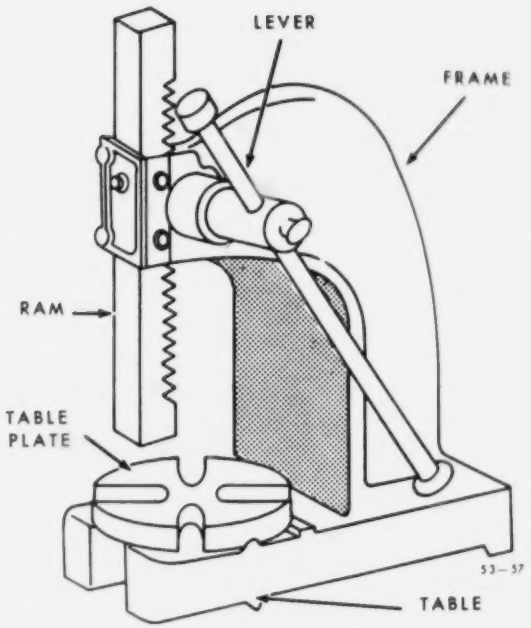

Figure 5-28. Arbor press.

269. Describe the operation of an arbor press.

Arbor Press. The arbor press is not really a forming tool in the normal sense of the word; however, since you will use it for forming metal, we include it in this section. In addition to the hand-operated type, hydraulic presses are often used to form aircraft parts from sheet metal stock. They are complex machines capable of developing many tons of pressure. The hand arbor press, however, is really a very simple machine. It is used to apply constant pressure to form flanges around holes, as well as to press into place bushings and other objects requiring a tight fit, where scarring or marring frequently associated with hammers and other driving tools is not allowable.

The arbor press consists of a ram held in a frame and actuated by applying pressure or force on the ram by the use of a lever. The lever is connected to the ram by a pinion gear. The force applied to the lever is transmitted through the pinion gear to a rack on the back of the ram. (See fig. 5-28.)

Using the arbor press is a simple task. Insert the proper size and shape of female die on the table which serves as the base for the arbor press. Insure that the material to be formed is free of all nicks and scratches which could cause the material to crack or fail. Then insert the metal between the male and female dies and apply a slow constant pressure with the ram pressing on the male die until the metal has conformed to the shape of the female die.

Exercises (269):

1. When would you use an arbor press?

2. How is pressure applied when using an arbor press?

3. Why is it recommended that all nicks and scratches be removed before forming a part using an arbor press?

270. Cite situations in which relief holes and lightening holes are used and the reasons for given characteristics of these holes.

Relief Holes. Wherever two bends intersect, material must be removed to make room for the material contained in the flanges. Holes are therefore drilled at the intersection. These holes, called relief holes, prevent strains from being set up at the intersection of the inside bend tangent lines. Such strains may cause the metal to crack. Relief holes also provide a neatly trimmed corner when the excess material is trimmed away.

The size of the relief holes varies with thickness of the material. They should not be less than ⅛ inch in diameter for aluminum alloy sheet stock up to and including 0.064 inch thick, or 3/16 inch for stock ranging in thickness from 0.072 to 0.128 inch. The most common method of determining the diameter of a relief hole is to use the radius of bend for this dimension, provided it is not less than the minimum allowance (⅛ inch).

Relief holes must touch the intersection of the inside bend tangent lines. To allow for possible error in bending, make relief holes extent 1/32 to 1/16 inch behind the inside bend tangent lines. It is good practice to use the intersection of these inside bend tangent lines as centers for the relief holes (see fig. 5-29).

Lightening Holes. Occasionally, holes are cut in rib sections, fuselage frames, and other structural parts to decrease weight. Such holes are known as lightening holes. To keep from weakening the member (by removal of the material), flanges are often pressed around the holes to strengthen the area from which the material was removed.

These holes should never be cut in any structural part unless authorized. The size of the lightening hole and the width of the flange formed around the hole are determined by design specifications. Margins of safety are considered in the specifications so that the weight of the part can be decreased and still retain the necessary strength. You may cut out lightening holes by any one of the following methods:

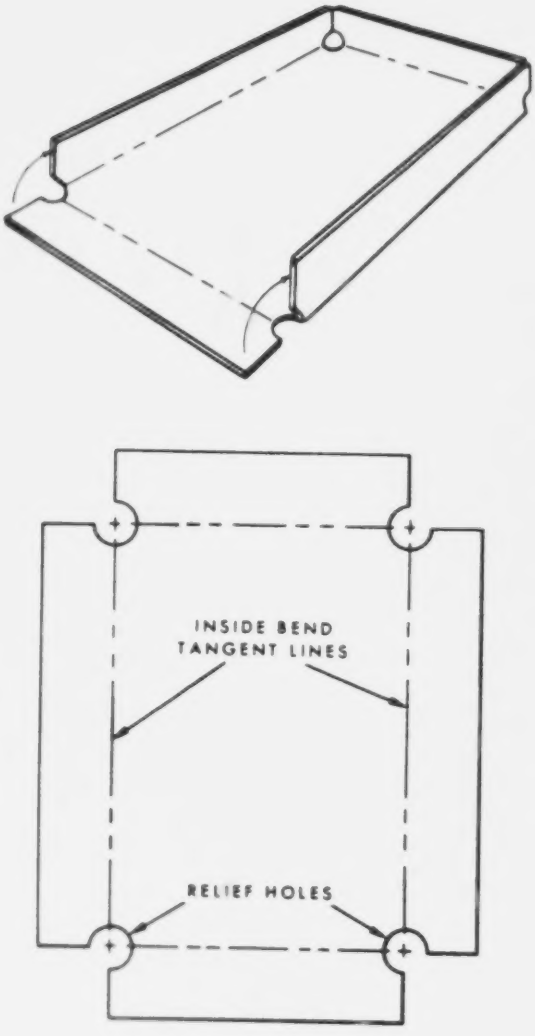

Figure 5-29. Locating relief holes.

a. Punching out, if the correct size punch die is available.

b. Cutting with a fly-cutter mounted on a drill.

c. Scribing the circumference of a hole with dividers and drilling around the entire circumference with a small drill, allowing enough clearance for proper smoothness after filing.

d. Scribing the circumference of the hole with dividers, drilling the hole inside the circumference large enough to insert aviation snips, cutting out excess metal, and filing to a smooth finish.

Form the flange by using a flanging die, hardwood, or metal form blocks. Flanging dies consist of two matching parts—a female and a male die. For flanging soft metal, dies can be of hardwood, such as maple. For hard metal or for more permanent use, dies should be made of steel. The pilot guide should be of the same size as the hole to be flanged, and the shoulder should be the same width and angle as the desired flange.

When flanging lightening holes, place the material between the mating parts of the die and form it by hammering or squeezing the dies together in a vise or in an arbor press. The dies will work more smoothly if they are coated with light machine oil.

Note the two form blocks shown on the left side of figure 5-30. The hole in the upper block is the same size as the hole to be flanged. The hole is chamfered to the width of the flange and the angle desired. In the lower block, however, the hole is the same diameter as that of the flange. You may use either type. When using the upper block, center the material to be flanged and hammer it with a stretching mallet, around and around, until the flange conforms to the chamfer. When using the lower block, center the lightening hole over the hole in the block, then stretch the edges, hammering the material into the hole, around and around, until the desired flange is obtained.

Occasionally, the chamfer is formed with a cone-shaped male die used in conjunction with the form block with which the part was formed as illustrated on the right in figure 5-30.

Exercises (270):

1. When are relief holes required?

2. On what layout lines are relief holes located?

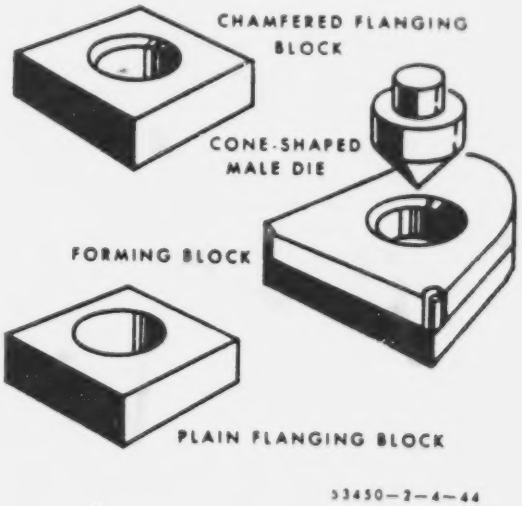

Figure 5-30. Flanging form blocks.

3. What factor directly affects the size of relief holes?

4. Why are lightening holes used?

5. Why are flanges usually formed around lightening holes?

CHAPTER 6

Metal Cutting

"HAND ME THAT nibbler." How many people outside the airframe repairman career field would know what tool was needed by the person making that request? When working with the tools of your trade, knowing the names of the different tools, how to maintain them, and which ones to use for a particular job are as much a part of the trade as using the tools themselves.

In the preceding chapter, we discussed the numerous ways to form and shape metal by using the forming tools and equipment found in the airframe repair shop. In this chapter, we cover the selection and maintenance of metal cutting, nibbling, punching, and abrasive tools.

6-1. Metal Shearing Tools

Shearing tools used in the airframe repair shops are of great value, and a variety of shearing tools and equipment is available for your use. When using shearing tools, remember that each has specified uses and limitations as to what materials it can be expected to shear under certain conditions. If the metal is too thick or hard, either the tool or the material can be damaged. Always, before using any machine, check the manufacturer's data plate for capacity, and read the operating instructions and safety precautions.

271. Cite factors governing the selection and use of specific types of hand-operated lever type shears.

Scroll Shear. The scroll shear, figure 6-1, has been designed for making both straight and irregular cuts on sheet metal. It is particularly adaptable for cutting on the inside of a sheet without cutting through the edge (inside cutouts). With this shear you can make many of the same cuts that are made with hand snips. The scroll shear can be used to make a very precise on-the-line cut, leaving a relatively smooth edge that requires only a small amount of finishing work.

The upper cutting blade is stationary while the lower blade moves. Pushing the handle downward raises the lower blade and produces the cutting action. When the handle is released, the lower blade returns to the DOWN position by spring action. When the blades are spread apart they leave a gap which allows material to be inserted for inside cuts. The size of parts which may be cut is limited by the frame or yoke.

Cuts must always be started from an edge, another cut or a hole. When cutting, it is preferable that the scrap material be on the side of the stationary blade and the good material on the side of the moveable blade.

Outside cuts (cuts around the outside of a pattern) should always start from an edge. Inside cuts should be started from a hole large enough to accommodate the point of the blade. If cuts are not started from an edge or from a large enough hole, the point of the blade punches through the metal and tears it. If a cut is to begin from another cut or from a hole, it is best to position the material so that the cut starts near the point of the blade. On the other hand, cuts made from the edge are more easily started near the center of the blades. While the cutting capacity of the scroll shear

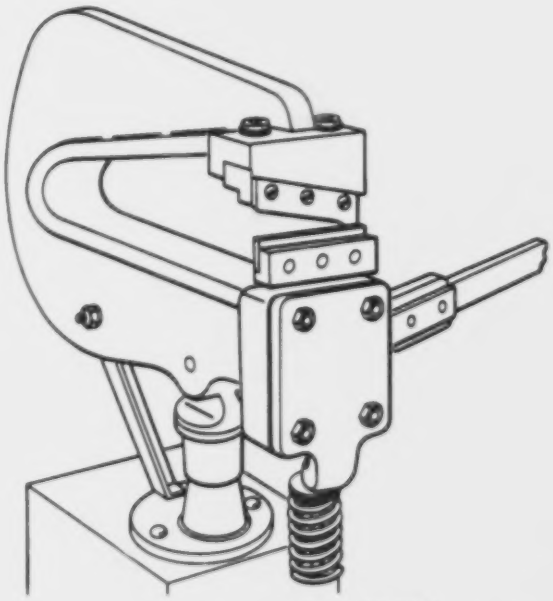

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Figure 6-1. Scroll shears.

varies with the type of metal, you should not try to cut metal thicker than .063 aluminum.

Observe ordinary safety precautions such as keeping your fingers away from the cutting blades and do not exceed the recommended material thickness while cutting.

Throatless Shear. Throatless shears (fig. 6-2) get their name from their construction. The frame of the shear never obstructs the cutting operation. This allows sheets of any length or width to be cut. The metal being cut may be turned in any direction, which allows for the cutting of irregular outlines and for making notches.

The throatless shear is quite sturdy and cuts heavier gage material than the scroll shear. The upper blade of the shear is directly connected to a hand lever. During the cutting operation, the upper blade moves down, shearing the metal. This motion tends to force the scrap down and away from the pattern.

The lower (fixed) blade should be kept in proper adjustment and inspected prior to use. If the blades are too close, they lose their sharpness and may be damaged. If the blade gap is too wide, the metal has a tendency to fold, causing a bad cut. The lower blade is adjusted with setscrews. Be sure to keep your fingers away from the cutting blades, to return the handle to full UP position after the cutting operations, and to protect your fingers and hands from burrs when guiding metal through the cutting blades.

Utility Lever Shears. Utility lever shears, shown in figure 6-3, are used for general work around an airframe repair shop and are especially useful for cutout work such as angles of specific degrees. The lower blade is attached to the table, making it possible to cut to the line with accuracy. The scribed line is always visible to the machine operator, permitting outside, straight, and irregular cuts. The upper blade moves up and down by means of a counterbalanced hand lever. In most cases, utility lever shears are equipped with an angle gage, miter gage, and depth gage. These gages assist in cutting duplicate pieces of metal to desired size and shape without repeated layout marking and machine adjustment.

The cutting blades of the utility lever shears vary in size from 6 to 9 inches and have a throat in the frame ranging from 9 to 20 inches. This machine is limited to cutting mild steel of 10 gage or less. Make sure that the gage of the material to be cut is within the capacity of the particular machine you use.

When operating utility lever shears, be careful to keep your fingers away from the cutting blades. During cutting operations, always return the counterbalanced wheel hand lever to the full UP position to prevent it from accidentally lowering the upper cutting blade.

Exercises (271):

1. What type of lever shears would you use to make cuts on the inside of a sheet of metal?
2. What determines the positioning of the metal on the blades of scroll shear for cutting?
3. Why is it possible to cut any length or width of cut with a throatless shear?
4. What type of cutout work is especially suited for utility lever shears?
5. When would you select a utility shear over a scroll shear?

272. Explain the setup and operation of a hand-operated circle shear.

Circle Shears. Circle shears (fig. 6-4) are used to greatest advantage when cutting circular blanks for cylindrical objects. These shears can also be used for slitting sheets and are equipped with a guide for that purpose. They are best suited for cutting disks from mild steel, copper, and aluminum.

The principal parts of the circle shears are the bed, yoke, and rotary cutters. The bed, since it must absorb and withstand the majority of the load and shock, is made of strong steel plate. On the top of this bed is a scale, with graduations to one-sixteenth of an inch, to indicate the approximate diameter of the circle you are cutting. The yoke, or sliding circle arm, centers and holds the sheet to be cut.

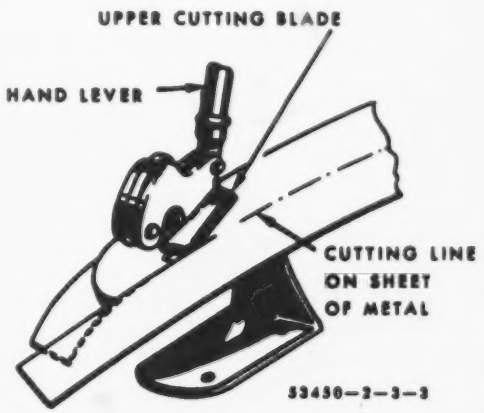

Figure 6-2. Throatless shears.

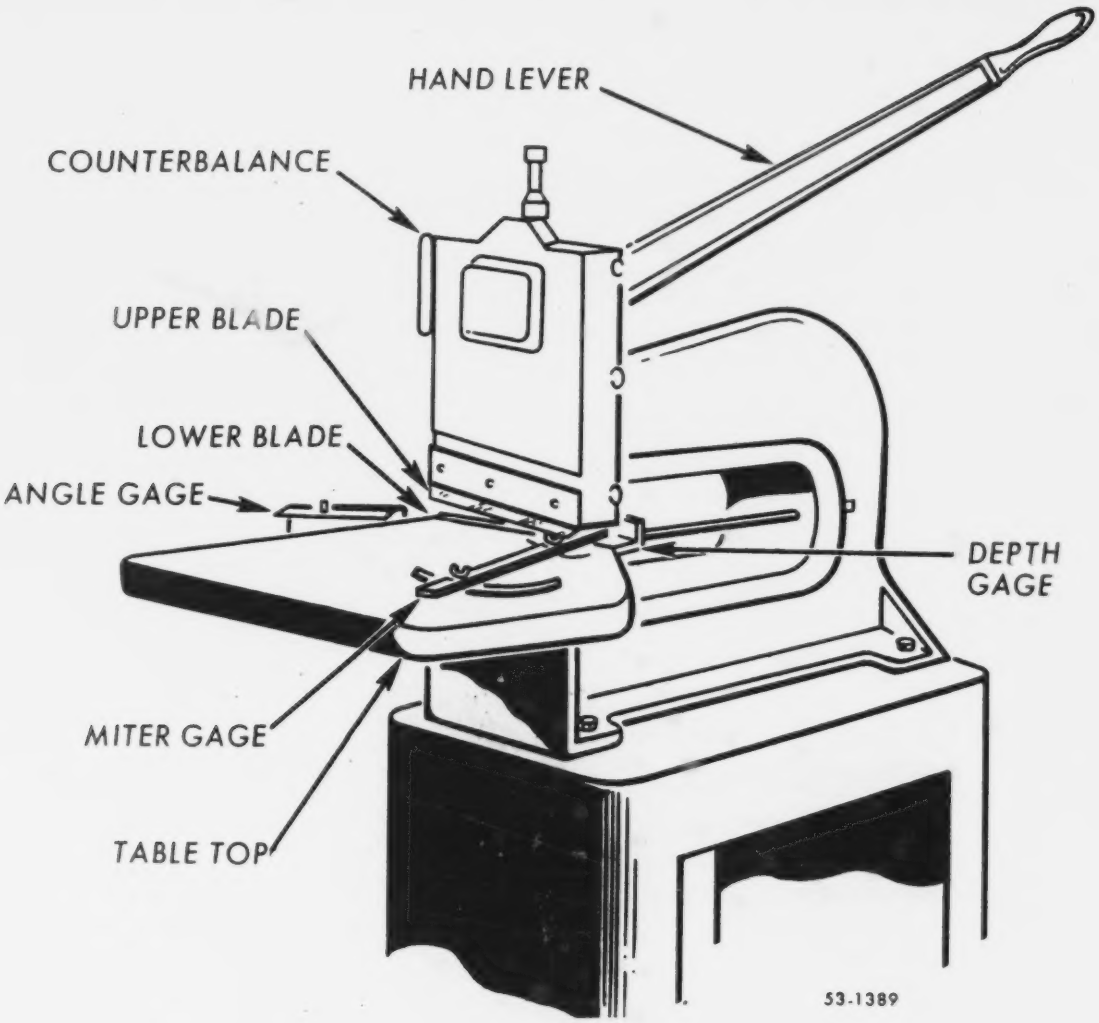

Figure 6-3. Utility lever shears.

To adjust the yoke, loosen the locknut (usually located at the base of the yoke) and slide it along the bed. Attached to the yoke is the clamping device which is operated by a clamping handle. Setscrews and locking nuts are used to adjust the pressure on these clamping devices. A hardened center pin in the lower disk aids you in centering blanks of center punched metal.

The upper rotary cutter on this machine can be adjusted vertically and should overlap enough to cut through the metal in one cut. The adjusting screw is usually located directly above the upper cutter. The bottom cutter can be adjusted in the same manner but in a lateral direction. For light gage metal, the cutters should just touch and operate freely. When cutting heavy material, the cutters should be separated slightly, but this opening should be limited to a maximum of 10 percent of the metal thickness.

When you are cutting circular blanks with circle shears, first cut the metal to approximate size. Place the blank between the clamping discs and adjust the yoke so that the distance from the center of the clamping disks to the cutting wheels is one-half the diameter of the blank desired. Then adjust the upper cutting blade with the vertical adjustment screw. You should stand at the side of the shears with the cutting head to your left when operating the machine with the handle so that the metal feeds away from you. Do not attempt to cut inside circles with this machine. Always start the cut from the edge of the sheet.

Safety precautions, when using circle shears, again include keeping your fingers from the cutters, gears, and burrs. When working with this machine (or any other gear-driven machine), make sure your clothing is not loose enough to get caught in the gears.

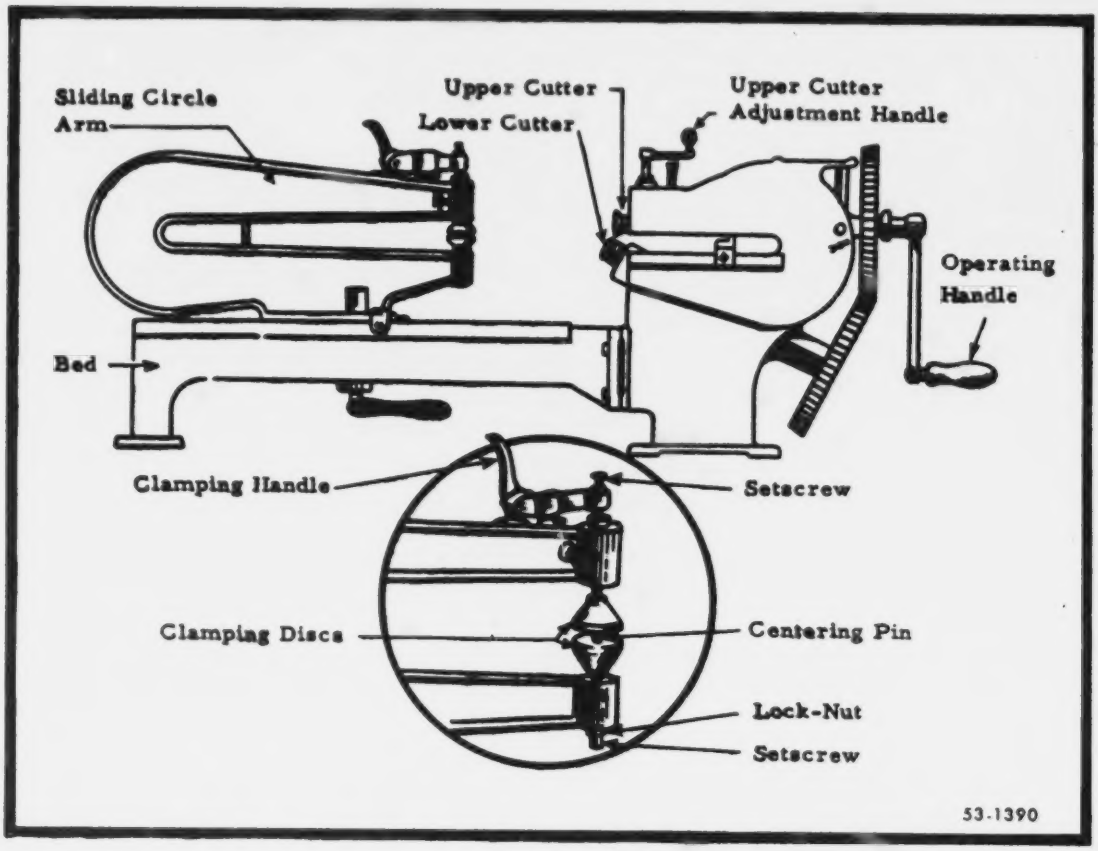

Figure 6-4. Circle shears.

Exercises (272):

1. What determines the positioning of the yoke when setting up a circle shear?

2. How should the rotary cutters be adjusted for cutting heavy gage material?

3. For thin gage material, how should the rotary cutters be adjusted?

4. What is the distance between the clamping disk and cutting wheels?

273. Give selected details of the operating procedures required when using the different types of squaring shears.

Perhaps the most important piece of stationary cutting equipment commonly found in the airframe shop is the squaring shear.

Manually Operated Squaring Shears. These shears are similar to power-operated squaring shears which will be discussed later. The foot supplies the action and power required to operate the cutting blade. The back gage and holddown handles are also manually operated. Although many types of foot-operated shears are manufactured, basically they are all similar. If you can operate one successfully, you should be able to operate the others.

The squaring shears illustrated in figure 6-5 have two large springs, one at each end of the housing, which raise the blade when pressure is removed from the treadle. A graduated scale is scribed on the bed as a guide for cutting correct lengths. At each end of the bed, there is a side gage which aids in keeping the metal square with the blades. After the first cut is made and it is found that the cut is not square, the error can be corrected by loosening the locking bolts and readjusting the side gage. If it is necessary to cut long sheets of metal that must be pushed from the back side, the two extension arms can be used in conjunction with

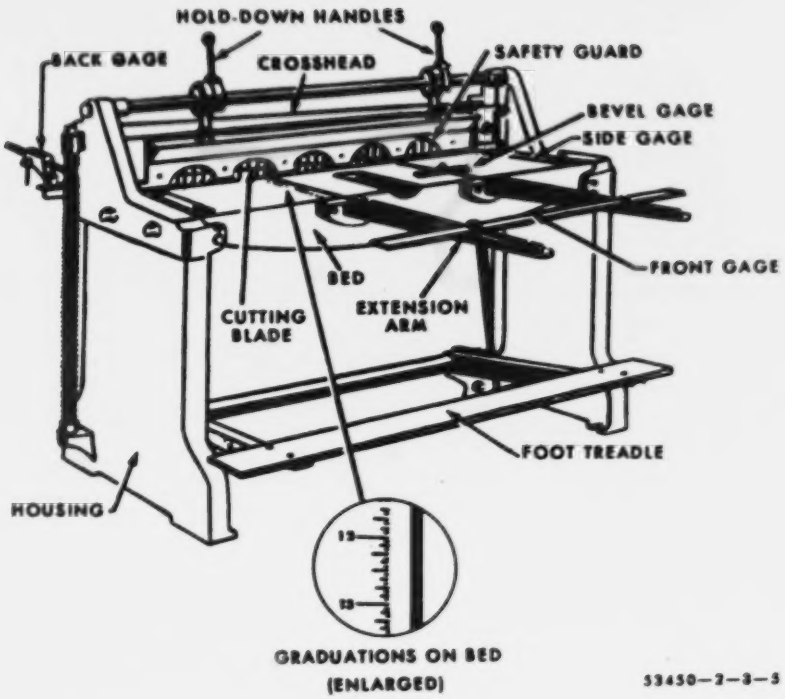

Figure 6-5. Manually operated squaring shears.

the front gage. The metal gage limit of this particular shearing machine is usually 16-gage mild carbon steel. If the metal is heavier, use power shears.

The holddown attachment on foot-operated shears can be either spring actuated or manually controlled. These holddowns, if adjusted properly, have an advantage over hand-holding, which usually allows the material to slip, causing inaccurate cuts. On very light or short cuts, accuracy of cut can be maintained on material held by hand.

The squaring shears are used for many necessary operations and save a great deal of work when cutting to a specific size. For cutting to a line, place the sheet on the bed of the shears in front of the cutting blade, with the cutting line even with the cutting edge of the bed. Pull the holddown handles forward to lock the metal in place. Then cut the material by stepping on the treadle, which completes the cutting cycle.

Squaring a piece of metal required several steps, the first of which is the trimming of one edge. Do this by inserting the metal between the blades of the shears and by cutting off approximately one-quarter of an inch of metal. Square the remaining edges by holding a trimmed edge against the side gage and by making the remaining cuts one edge at a time.

For cutting several pieces of metal to the same dimensions, use the back gage (production gage). This gaging device, shown in figure 6-5, consists of two support rods, graduated in fractions of an inch, and a square fence that can be set at any point on the support rods. To use the gage, set the squaring fence at the desired distance from the cutting blade by loosening the locking knobs and turning the adjusting knobs. After all adjustments have been made, lock the fence in position and insert the metal between the blades of the shear until the edge of the metal comes in contact with the squaring fence. To insure accuracy of cut, be sure that the edge of the metal is flush all along the fence. Then pull the holddown handles to clamp the metal. The successful use of this gage depends upon a few predetermined adjustments; once the gage adjustments are made, many pieces of metal can be cut to the same dimensions without additional measuring.

Safety precautions to be observed when using manually operated squaring shears are practically the same as those for power-operated squaring shears. However, when pushing down on the foot treadle, which requires considerable force, be sure your other foot is clear of the foot treadle.

Power-Operated Squaring Shears. Squaring shears, illustrated in figure 6-6, provide a convenient means of cutting and squaring sheet metal stock. Learn how to use this machine properly because it will, among other things, increase production.

A major difference between the foot powered shear you have been using and the power-operated shear is the operation of the holddown. When the trip levers of the power shear are compressed the holddown automatically moves down, clamping the metal into place. This is a convenient feature, but it is also a very dangerous one. The holddown exerts tremendous pressure and will completely smash any finger or hand which is carelessly placed under it.

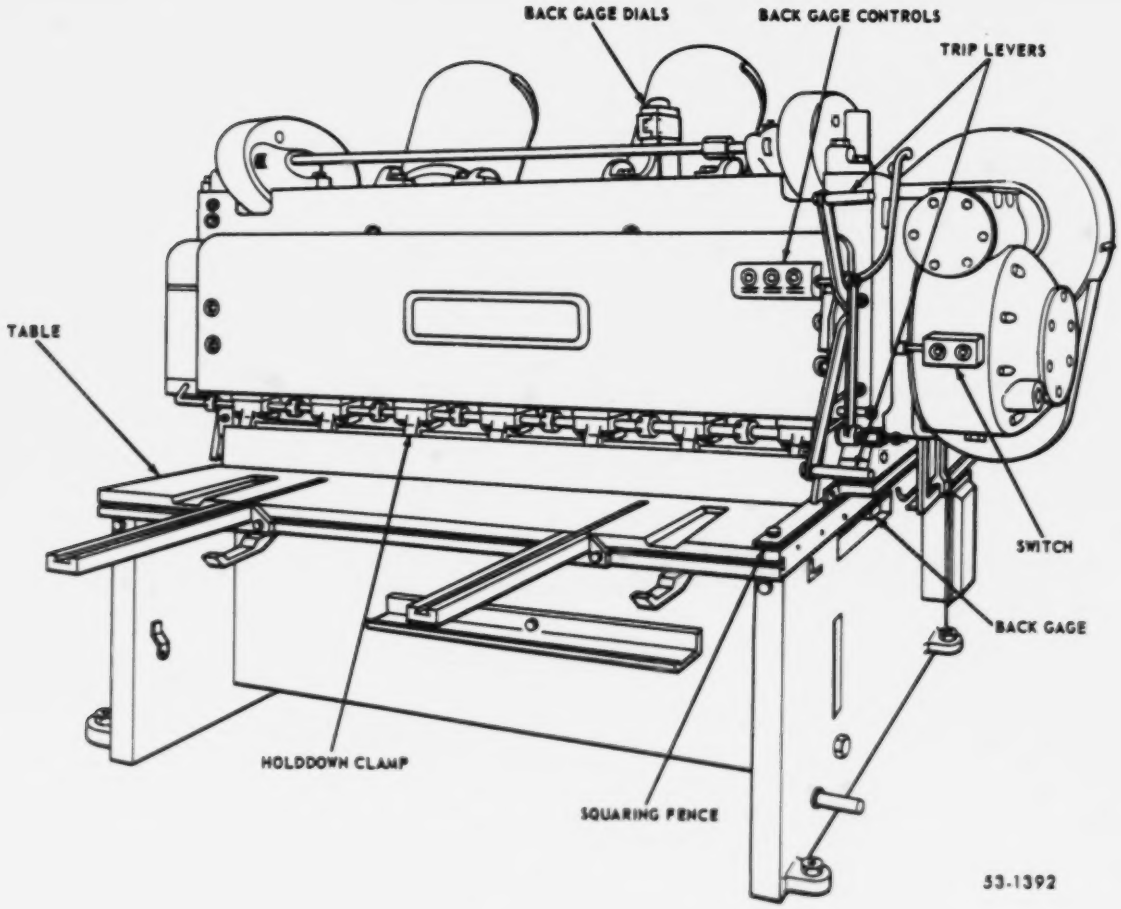

Figure 6-6. Power operated squaring shears.

Before using the shear you should check the data plate (usually found on the front of the shear) to see that the gage of material being cut is within the capacity of the shear. Cutting procedures on this shear (squaring metal, cutting to a line, and multiple cutting) are similar to those for the foot operated shear. If adjustments are needed for the cutting operations, they should always be made before the motor is started or after the motor is turned off. DO NOT ADJUST THIS MACHINE WHILE THE MOTOR IS RUNNING.

The table of the power shears has extension arms, similar to the manually operated shear, which provide support for long sheets of metal. Extending to the right of these arms, but still on the bed, is a guide graduated in sixteenths of an inch. This guide can be used as a measuring scale for cutting short lengths of metal. It also keeps the metal square with the blade when adjusted correctly. The guide is not shown in figure 6-6, since the machine as illustrated is set up to cut long sheets of metal. However, it is similar to the side gage of the manually operated squaring shears shown in figure 6-5. Control switches are provided for operating the power shears. The back gage is adjustable and can be moved forward or backward, depending on the length of cut required. There is no need to measure between the back gage and the fixed horizontal blade because all measurements can be read on the back gage, graduated in sixty-fourths of an inch.

By compressing the trip levers together, you engage an automatic clutch which sets the shearing blade in action. The shears go through only one cycle of action each time the trip levers are compressed and released. If continuous operations are desired, simply continue to hold the levers together. Once the trip levers are released, the machine stops when it completes the cycle of operation. Be sure to turn off the shears after all cuts are made and remove the material that has just been cut.

NOTE: On other model power squaring shears, a treadle is used to engage the automatic clutch. Follow the same operating procedures for the number of cutting cycles, as earlier stated for the trip levers.

Before operating power shears, you should check the machine to see that it is clear of material and personnel. For instance, someone might be making repairs behind the machine. If power to the machine is turned off, there is usually a reason; therefore, check with your supervisor for the cause. In some shops a "Caution Repair" tag is used to identify the status of the machine. If there is such a tag on the machine, do not attempt to remove it. The person making repairs will remove it when the work has been completed. The machines you use are equipped with guards for your protection, and the guards should never be removed except when the machine is disconnected from its power source for repairs. The blade guard is not visible in figure 6-6, because it is located between the holddown dogs and cutting blade. The blade guard, similar to the safety guard shown in figure 6-5, is designed to keep your hands and fingers away from the cutting blades during operation. Wheel and belt guards are provided to protect personnel and to keep foreign objects from being caught in the moving parts. When making cuts, always make certain that the cutting blades are clear before releasing the clutch to actuate the holddown dogs and the blade. Make sure that your fingers are clear of the holddown dogs when they are actuated, because to keep your metal in place during shearing, tremendous pressure is applied. These dogs have been responsible for the loss of as many fingers as has the shearing blade.

Gap Squaring Shears. The gap squaring shears, illustrated in figure 6-7, resemble manually operated squaring shears except that the frame is built to accommodate any width or length of sheet metal stock for slitting. The front opening or gap is usually about 18 inches deep for shears with a capacity of 16-gage mild steel. These shears have a supporting table on the left side to keep the sheet level with the surface of the bed; on the right side is another guide used in slitting long sheets of metal. Constructed as they are, these shears can be used to cut one piece or several pieces from a sheet of metal longer than the machine. This type of work is done by first adjusting the front gage to the desired width, making sure that the gap is deep enough to allow easy passage of the metal. The metal is moved between the cutting blades from left to right, and a cut is made about three-quarters the length of the blade. Then the holddown levers are released and the sheet moved to the right so that the edge of the metal will ride against the guide. This is repeated until the cut is completed.

Safety precautions when operating gap squaring shears are similar to those precautions for manually operated squaring shears.

Exercises (273):

1. When would you readjust the side gage on a manually operated squaring shear?

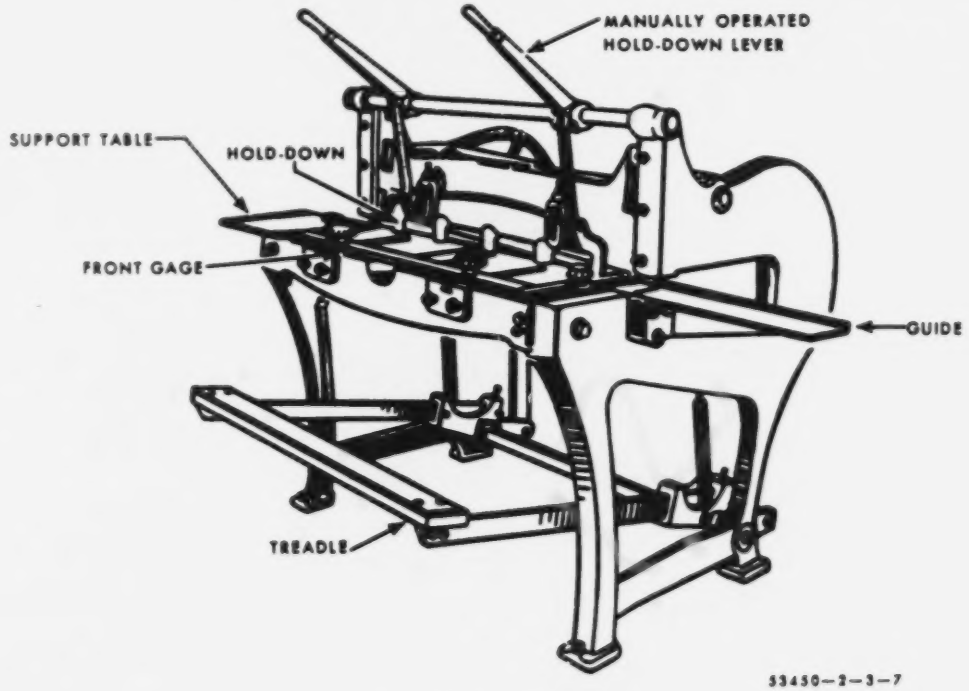

Figure 6-7. Gap squaring shears.

2. When would you adjust the back gage on a manually operated squaring shear?

3. Describe the procedures for squaring a piece of metal with a manually operated squaring shear.

4. How does the operation of the holddown on a power-operated squaring shear differ from a manually operated squaring shear?

5. What must you do before operating a power-operated squaring shear?

274. Cite specific operating procedures for the use of unishears.

Unishears. You will find unishears useful equipment in the airframe repair shop. Figure 6-8 illustrates the stationary type. Like the portable type, it cuts along irregular lines on sheet stock and saves you much time, since it cuts faster than hand snips or shears.

The stationary unishears, illustrated in figure 6-8, are powered by an electric motor which moves the lower cutting blade up and down to cut the sheet stock as it is guided through the blades. It is possible to make straight or irregular cuts through sheet stock as heavy as 16 gage. The upper cutting blade does not reciprocate during cutting; however, the upper blade positioning assembly can be raised with the upper blade positioning lever when it is necessary to open the throat of the shears to make inside cuts. The blade is lowered before the machine is operated. The cutting blades are adjusted for clearance when new blades are installed; therefore, they do not need readjustment for different gages of metal stock. A red safety light, located near the ON-OFF switch, is illuminated when the motor is operating. The grease cup located in the gearcase is packed with gear lubricant and must be tightened by hand to lubricate the moving parts.

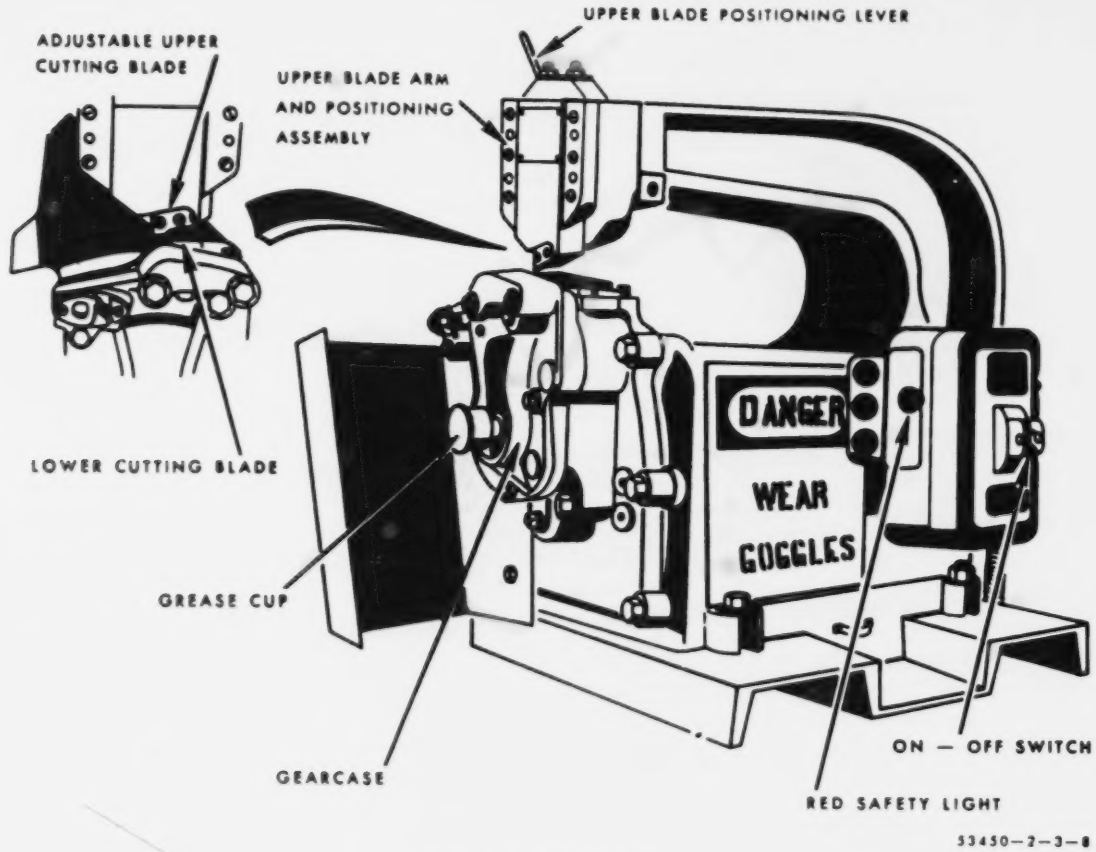

Figure 6-8. Stationary unishears.

In figure 6-9, you can see how irregular cuts in sheet stock are made with electrically driven portable unishears. Notice how the shears are guided through the metal. This is rather easy to do, because the shears are throatless and can be turned to the right or left without releasing the forward pressure. Portable unishears can be held in either hand and are used in the shop if electrical power is available.

CAUTION: Electrically driven power tools are NEVER used on aircraft, because of the danger of explosion due to sparks created by the electric motors.

Accuracy when cutting with either the stationary or portable unishears is determined by the operator; therefore, it is important to align the upper cutting blade with the line being cut in the metal. If you look a few inches ahead of the cutting blades, you should get better results. Apply just enough pressure to insure that the blades are cutting smoothly at all times. Too much pressure will overload the machines, and too little pressure will cause the metal or machine to jump from side to side, resulting in very sharp burrs.

Observe certain routine safety precautions when using either of these unishears. Keep your hands and fingers clear of the cutting blades at all times, and avoid the burrs. Keep the power cord of the portable unishears clear of the burred edges to prevent damage to the insulation of the cord. Check the three-prong connector on the power cord before connecting it to a properly grounded power receptacle.

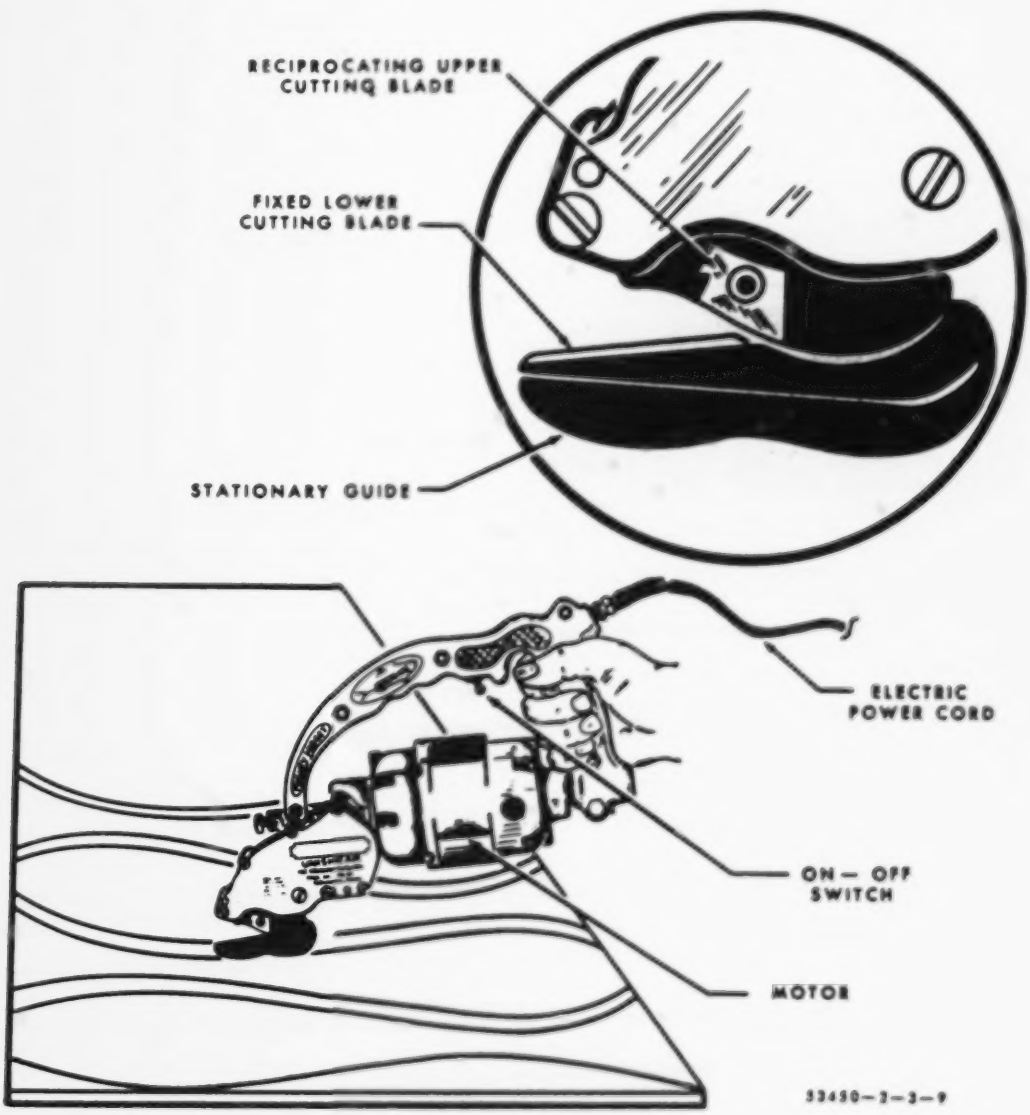

Figure 6-9. Portable unishears.

Exercises (274):

1. If you had to make a number of inside cuts on a large sheet of metal, which type of unishear would you select?

2. When are the blades adjusted on a stationary unishear?

3. What construction feature allows the portable unishear to be turned right or left without changing the cutting pressure?

4. Which blade on the unishear should you use for alignment when cutting?

5. What causes a very sharp burr on the edges of metal cut with a unishear?

6-2. Power-Operated Saws

Many times you may find it impractical to use metal shearing tools because of the material composition, thickness, or shape of the metal you are working with. In such cases, it is necessary for you to use some other type of power-operated cutting tool. Among the most frequently used cutting tools are the various types of ketts saws, hole saws, reciprocating saws, nibblers, band saws and contour metal cutting saws.

275. Given a work situation, select the proper hand-operated power cutting tool.

Ketts Circle Saw. The circular cutting ketts saw, illustrated in figure 6-10, is portable, electrically operated, and uses blades of various diameters. The following are some of its advantages: It can cut metal up to three sixteenths inch thick; it does not need a starting hole; a cut can be started anywhere on a sheet of metal; and it will cut an inside or outside radius. The head of the saw can be turned to any desired angle; it is very handy for removing damaged sections of a stringer.

If you do not maintain a firm grip on the saw handle while cutting, the saw will grab the material and may injure you or damage the metal. The most important thing to remember, before you use the saw, is to check the blade for cracks before installation. A cracked blade can fly apart and result in serious injury to people nearby.

Hole Saws. Hole saws, such as illustrated in figure 6-11, are used to cut holes in light-gage sheet metal stock and wood. They may be obtained in sizes up to 4-inch diameter. A ¼-inch drill is recommended for hole saw sizes up to 1½ inches, and a ½-inch drill is recommended for sizes up to 4 inches in diameter. This saw is very well adapted for cutting holes in skins and sheet stock to be used for panels and cover plates, since these items are usually fabricated with light-gage steel. When drilling with hole saws, use only enough pressure to cut evenly. Too much pressure will cause the saw to bind and create excessive strain on the saw and metal.

Circle Cutters. Circle cutters like those illustrated in figure 6-12 are used with slow-speed pressure in both portable drills and drill presses in a similar manner and for the same purpose as hole saws. However, the circle cutter differs from the hole saw in one respect—the circle cutter may be adjusted for different sizes and depths of cuts. In figure 6-12 you see the setscrew wrench, used to loosen and tighten the setscrews or to remove the twist drill. The adjustable arm enables the circle cutter to be used for cutting circles of different sizes, and raising or lowering the cutting blade makes it possible to regulate the depth of the cut. During use, the circle cutter must be held firmly and perpendicular to the material being cut, and the material must be securely held or clamped. Circle cutters are sometimes called fly cutters.

Reciprocating Saw. This saw, illustrated in figure 6-13, is portable, air-powered, and has a gun-type shape for balancing and ease of handling. It operates most effectively if the supply of air pressure is from 85 to 100 pounds per square inch. It uses a standard hacksaw blade cut to proper size, and, because of the adjustable collar, can be used to cut either a 360° circle, a square hole, a rectangular hole, or any degree

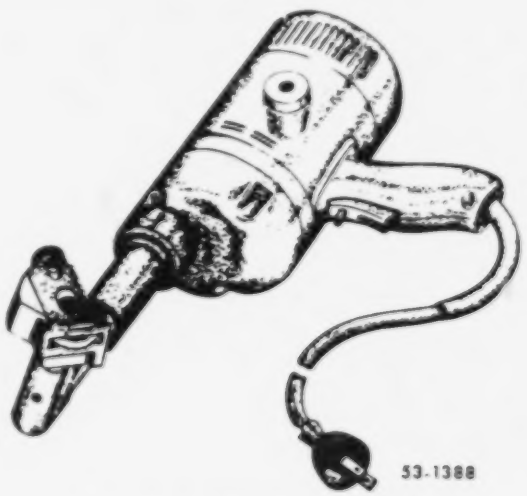

Figure 6-10. Ketts circle saw.

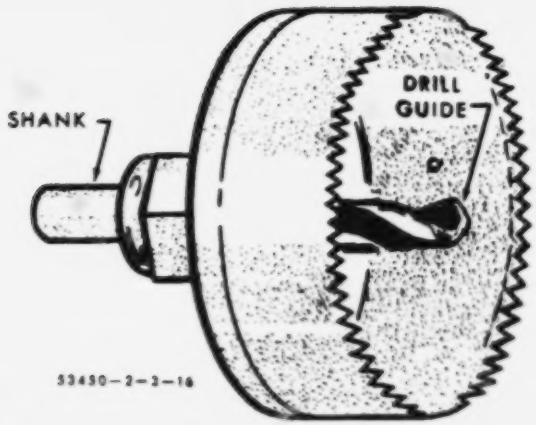

Figure 6-11. Hole saw.

of inside or outside cut. This saw, because of its shape, is easy to handle and safe to use with minimum safety procedures.

A reciprocating saw is used in such a way that at least two teeth are on the cutting surface at all times. When cutting with the reciprocating saw, avoid applying too much downward pressure on the saw handle, as this may cause the blade to break or bend. When installing a replacement blade, remember that the teeth must face toward the handle.

Nibblers. Nibblers are used to cut metal by a high-speed blanking or cutting action. This action is accomplished by up and down motions of the lower die. The shape of the lower die permits small pieces of the metal, approximately 1/16 inch wide, to be blanked or cut out as the motion of the lower die presses the metal against the surface of the upper stationary die. The cutting speed of the nibblers is controlled by the thickness of the metal being cut. Sheets of metal with a maximum thickness of 1/16 inch can be cut satisfactorily. Too much force applied to the metal during the cutting operation will clog the dies, causing the dies to fail or the motor to overheat. The lower die has a spring-loaded adjustment screw located at the base of the die which controls the movement of the metal. This screw should be adjusted so that the metal moves freely between the dies and, at the same time, be held firmly enough to prevent irregular cuts. The dies can also be shimmed for special cutting.

Exercises (275):

1. If you had to remove a damaged section of a stringer, which type of power-operated saw would you select?

2. Cutting holes in light-gage skin and sheet stock to be used for panels and cover plates can best be accomplished using what type of saw?

3. For cutting square or rectangular cutouts, which type of saw should you select?

4. What controls the cutting speed when using a nibbler?

5. What will cause the cutting dies to fail when using a nibbler?

276. Describe specified steps or criteria for the set-up and operation of a contour metal cutting saw.

Contour Metal Cutting Saw. Of all the machines you use, the contour metal cutting saw is probably the greatest challenge to your resourcefulness and skill. The contour metal cutting saw, such as the DO ALL shown in figure 6-14, is designed to make straight or irregular cuts. The contour saw is used in the repair and replacement of aircraft fittings or parts made of a material too heavy to be stamped out or cut by shears. It can also be used to advantage when a number of similar parts are to be cut from sheet stock. For this operation, fasten roughly cut pieces of sheet metal together by weld, solder, rivets, or clamps, and cut all the pieces at the same time. With the proper blade, and using the job selector dial as a guide, you may adjust this machine to cut many types of metal. The saw illustrated may be hand or power fed; however, you will use the manual feed process most of the

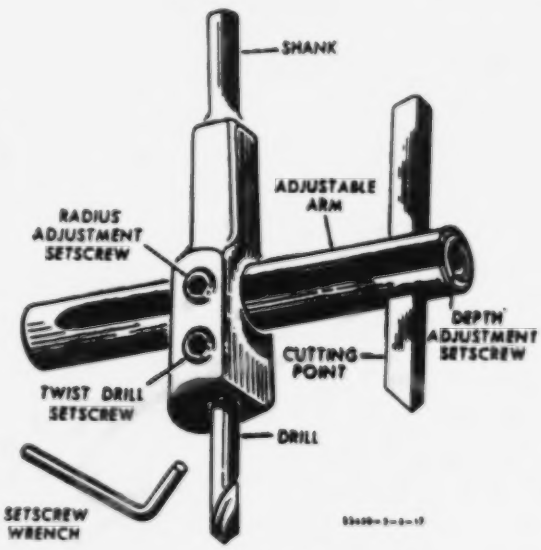

Figure 6-12. Circle cutter.

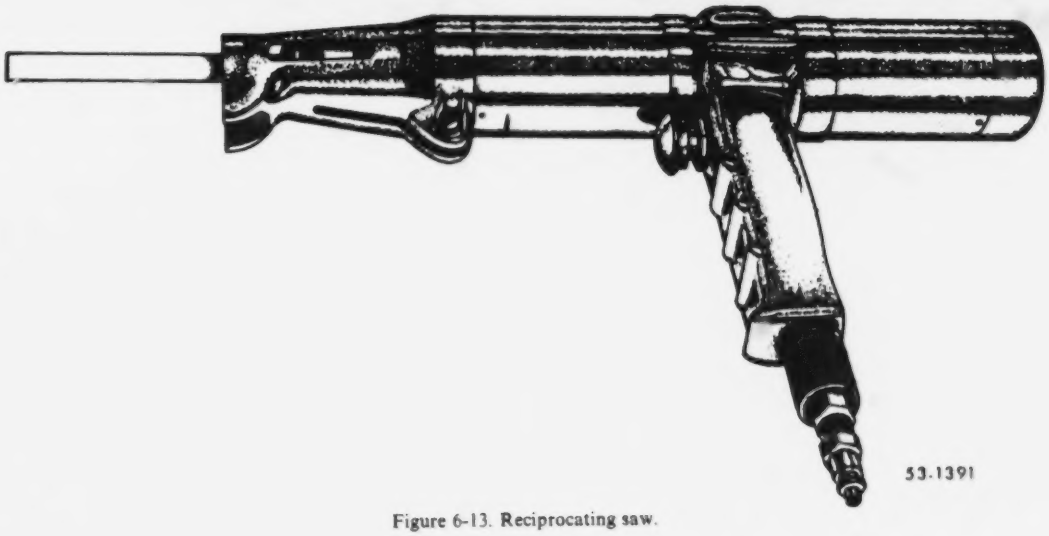

Figure 6-13. Reciprocating saw.

time. *Safety*, especially with this machine, is a *must*.

The contour saw has several speeds, both hand and automatic feeds, and an arrangement by which the table can be adjusted to any angle. Some saws are equipped with butt welding and grinding attachments which permit the saw blade to be cut, inserted, and welded without delay when making internal cuts. This equipment can also be used to mend broken blades. Continuous file bands and polishing bands are available as accessories for finishing parts once they have been cut. Successful sawing depends on three essential factors:

a. Selection of the saw blade.
b. Joining (welding) the saw blade.
c. Mounting and adjusting the saw blade.

Selection of the saw blade. There is a *best* saw blade for every sawing job. You must know the various features of the saw blade and the types of saw blade that are available in order to select the proper saw blade for a given job. Every saw blade is made of a high grade tool steel, designed for a specific purpose and constructed to close tolerances to assure uniformity of quality. Before you can select a saw blade, a knowledge of saw blade terms is a must. Refer to figure 6-15, as we discuss the following terms:

a. Teeth: Front edge or cutting part of a blade. It is mainly from the general tooth shape and tooth spacing that the blade gets its name or type.
b. Tooth Gullet: The throat or opening within the curved area at the base of the tooth, tooth face, and the back of the next tooth. It removes chips from the cut.
c. Width: Measurement of the blade from tooth tip to the back edge of the blade. Saw widths may vary from 1/16 to 12 inch.
d. Thickness of the blade. (For saws up to ½ inch width, the gage is usually .025 inch.)
e. Set Pattern: The pattern formed on the teeth depending on the manner in which the teeth are set. There are three set patterns: raker, wave, and straight.
f. Pitch: Number of teeth per inch.
g. Set: The amount of bend given the teeth. This makes it possible for a saw to cut a kerf or slot wider than the thickness of the blade back (gage) thus providing side clearance.

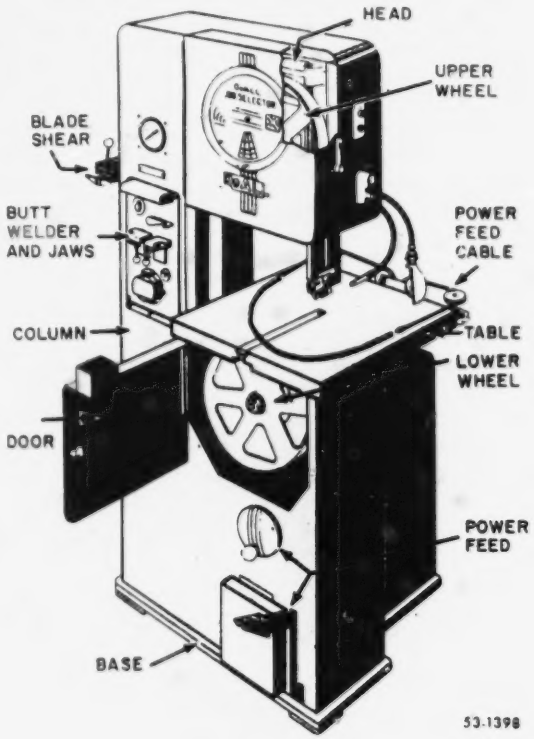

Figure 6-14. Contour metal cutting saws.

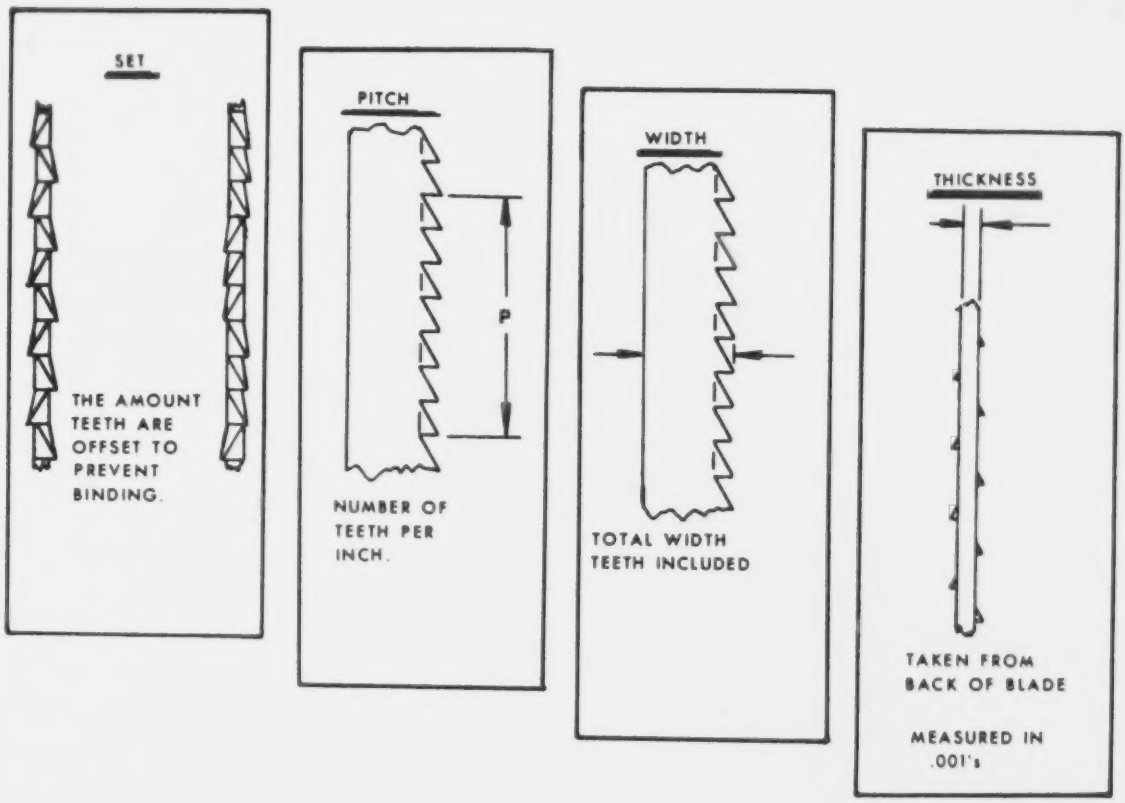

Figure 6-15. Saw blade features.

A job selector dial, figure 6-16, is mounted on the upper door of the machine. This dial serves as a quick, convenient source of operating recommendations for the saw. It recommends a type of blade and saw speed that should be used for each type and thickness of material that can be sawed on the saw.

The outer dial of the job selector contains the names of various types of materials. To use the job selector, turn this dial until the desired type of material is listed in the bottom position. Recommendations for cutting this type of material will appear in the vertical slot of the inner disk.

In addition to the recommendations for cutting specific materials, the job selector also indicates the smallest radius that can be cut with a particular width of blade. This is indicated on the left side of the job selector disk. Always remember to select a blade that has at least 2 teeth engaged in the work at all times. Too few teeth per inch allows the possibility of teeth straddling the material and being stripped.

Joining (welding) the saw blade. After selecting the correct saw blade, you must weld it properly to obtain good service. The butt welder unit, built into the frame of the machine, is an essential piece of equipment for joining new blades and for rejoining blades for internal sawing.

The butt welder panel assembly (fig. 6-17) shows the general arrangement of the panel. At the top of the panel there is a 15-watt lamp and on either side of the panel are two oil fillers. The spring cap oil fillers are connected by copper tubing to the sleeve bearings of the grinder motor.

Below the oilers is the tension control dial or weld selector which regulates the tension of the movable jaw for different widths of saw blades. This dial is mechanical and enables you to control the pressure with which the movable jaw moves toward the stationary jaw. Wider saw blades need greater tension than smaller ones. Too much tension on small saw blades causes climbing or lapping.

Directly below and to the right of the tension control is the welder operating lever (weld lever), which acts as a combination welding switch and as a lever to exert pressure on the movable jaw. The welder jaws support the blade during welding and annealing. The movable jaw moves the blade approximately .040 inch pressing the molten blade ends together during the welding operation. Directly below the movable welder jaw is the annealing switch which is a red bakelite button held out under spring tension. This is not a snap switch; it should be pushed in to a hard stop and held during annealing. To the left of the annealing

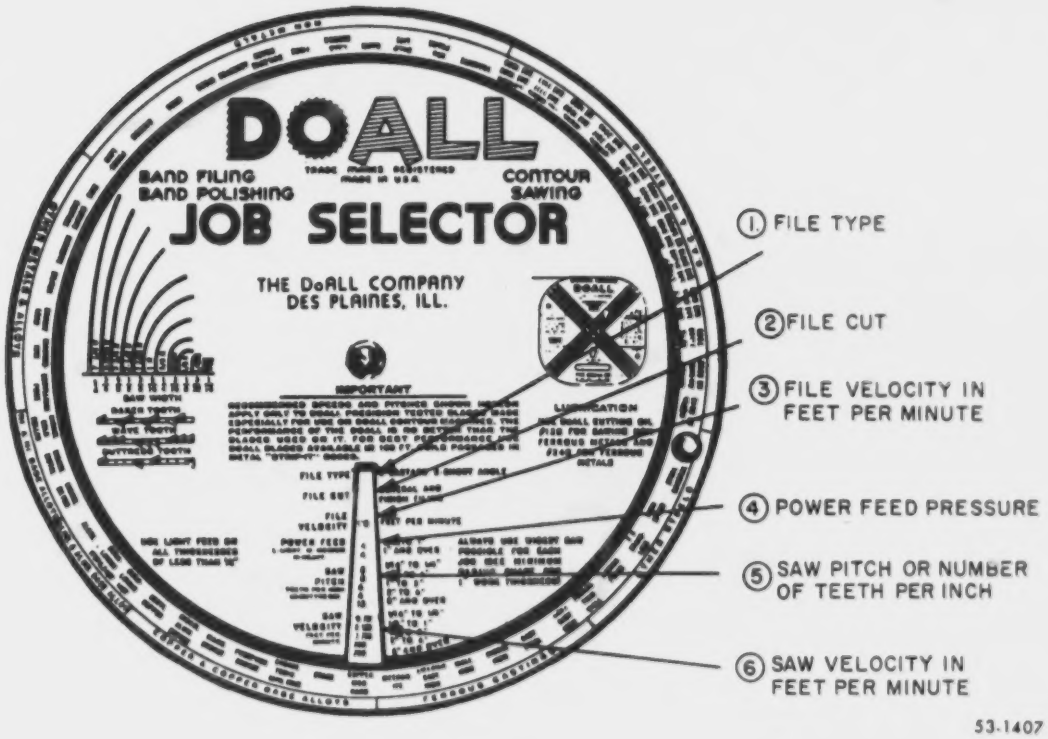

Figure 6-16. Job selection dial.

switch is the grinder motor switch. Below the welder jaws is the grinder, which is used to square the ends of the saw blade and to grind off the excess metal from the weld. Above the grinding wheel guard is a gage to test the saw thickness after grinding. The saw blade weld, when ground properly, will pass freely through the gage.

You should have no problem in welding a saw blade using the following procedures:

1. Cut off a saw blade of the desired length.
   NOTE: Cut the blade from the back toward the teeth.
2. Grind the ends of the blade square against the side of the grinding wheel.
3. Insert the ends of the blade into the jaws with the teeth towards you.
4. Clamp the blade in position by turning down on the thumb screws.
5. Set the tension control switch to the correct position for the width of the blade.
6. Set the line voltage regulator for the correct welding heat with a small screwdriver or coin.
7. Turn the flash guard down.
8. Press the operating lever down to make the weld and hold it until the weld has cooled.
9. Loosen the thumb screw on the stationary jaw clamp before releasing the operating lever, then release the saw blade from the movable jaws.
10. Move the saw blade from the welding position forward to the wide-gap annealing position.
11. Reclamp the saw blade just back of the teeth.
12. Press the annealing switch button until the welded area comes up to a dull cherry red.
    NOTE: Turn off the welding light so that the correct annealing heat can be determined.
13. To cool the annealed portion gradually, press the annealing button two or three times during the cooling period.
14. Remove the saw blade from the jaws and grind off the welded portion on both sides of the blade until the weld is the same thickness as the saw blade. Use the gage directly above the grinding wheel to check for correct thickness.

CAUTION: Avoid grinding the set off the teeth.

When it is necessary to cut an installed saw blade for internal sawing, always cut out the original welded area of the saw blade. Only one welded area is allowed on a saw blade.

Mounting and adjusting the saw blade. Before installing the saw blade into the machine, correct size saw guides and inserts must be installed. Upper and lower saw guides are provided to give rigid support and to position the saw band at the point where cutting occurs. The saw guide block assembly consists of a cast iron guide block and two inserts. There are two sets, an upper set mounted on the guide post, and a lower set mounted on the keeper block, below the work table. Along with the guides are three gages for setting the inserts for the various sizes of saws. For

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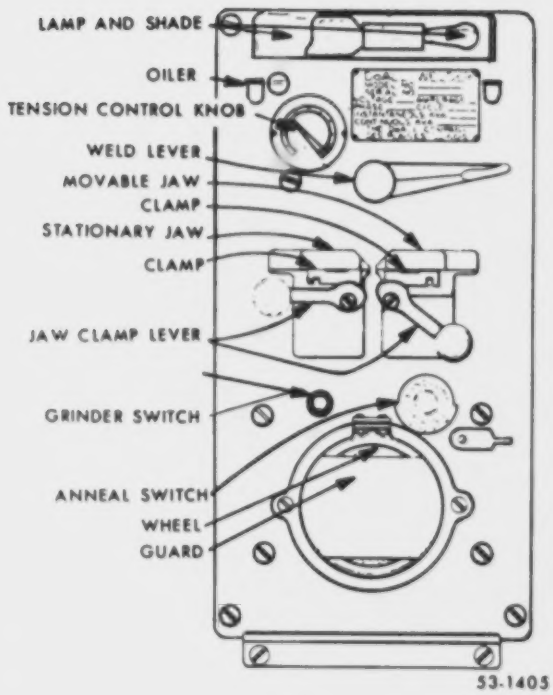

Figure 6-17. Butt welder.

saws of 1/16 to 1/2 inch the .025 inch gage is used, from 5/8 to 3/4 inch the .032 inch gage is used, and for a 1 inch saw the .035 inch gage is used. The inserts are hardened steel and are ground in pairs of a right and left hand. They fit the slot in the guide block and are held in place with Allen head screws. When the inserts are worn so that the saw slot is not parallel, they should be reground to a true 45° angle and stoned or honed with a slight radius on each edge. Do not grind the flat or notched surfaces. They are accurately determined at the factory and are not subject to wear.

Procedures for mounting the saw guides and inserts are shown in figure 6-18. Refer to this figure as we discuss the following mounting steps:

1. Select the upper and lower saw guide assemblies.
2. Select the inserts corresponding to the width of the saw to be used. (Inserts that are too narrow will not support the saw properly, while inserts that are too wide will damage the saw set.)
3. Place the left-hand insert in the milled slot and tighten the screw lightly so the insert will slide but will hold the position as in figure 6-18, A.
4. Insert the gage on the opposite slot as shown in figure 6-18,A, and adjust the insert so that it meets the gaging edges; then tighten the screw.
5. Remove the gage and mount the right-hand insert.
6. Adjust the right-hand insert a distance from the left-hand insert equal to the thickness of the gage as in figure 6-18, B.
7. Repeat this operation for the lower saw guide block.
8. Mount the upper guide on the guide post and the lower guide on the keeper block, as shown in figure 6-18,C and D.

Installing a saw blade is a simple process, but definite procedures should be followed. First, lower the upper wheel by means of the blade tensioning handwheel. (Lower the wheel enough to insure that the blade will fit around both the upper and lower wheels.) Grasp the right-hand portion of the blade in both hands, with the hands spaced about 10 inches apart. Pass the blade into the table slot. Be sure the teeth on the portion of the blade in your right hand are pointing toward you and downward.

As the blade approaches the front table trunnion, tilt the portion of the blade above the table to the right and the portion under the table to the left. Tilting the blade in this manner allows it to pass the front table trunnion. After the blade has passed the trunnion, return the blade to an upright position so it will pass through the remainder of the slot and then into the opening in the center of the table.

Thread the upper portion of the blade between the telescoping guard and upper wheel and finally around the lower wheel. Hold the blade in position on the upper and lower wheel and increase the blade tension to the desired amount by means of the blade tensioning handwheel.

The tension of the saw is adjusted through the upper saw wheel, actuated by handwheel, shown in figure 6-19. This handwheel allows a 6-inch adjustment to the wheel. There is no hard and fast rule by which the correct blade tension can be obtained. In general,

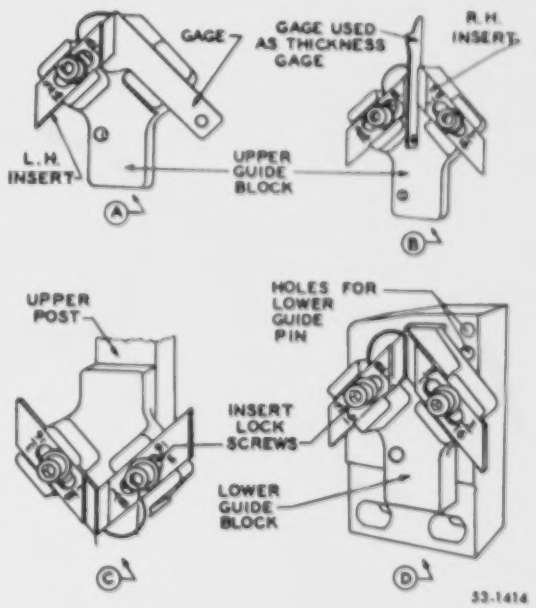

Figure 6-18. Mounting inserts and guides.

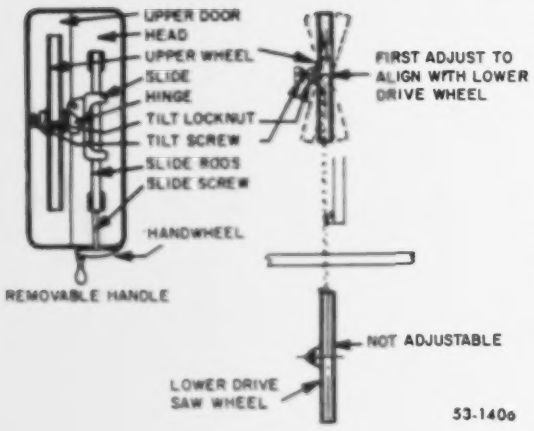

Figure 6-19. Tilting wheel for saw alignment.

tighten new blades taut to prevent them from twisting or wavering in the kerf. After they have been used, they stretch slightly and require readjustment. Blades ⅛ inch or less require less tension to hold them in line during cutting. A taut blade gives the best sawing results, keeping the saw blade in the true cutting path. Correct tension on the saw blade can be determined only through experience. Generally, it is better to have the blade too taut than too loose. A new saw blade must be checked frequently for the proper tension due to the stretching of the new saw blade.

After the proper tension is obtained, the upper wheel must be adjusted (tilted) to provide proper tracking of the blade. Do this by standing to the right of the machine so that the tracking adjustment screw, as shown in figure 6-19, can be reached with the right hand and the upper wheel with the left hand. Revolve the upper wheel by hand with the machine in neutral. By using the adjusting screw at the center of the upper wheel, adjust the tilting wheel until the saw runs in the guides with its back edge touching the rollers.

The tracking adjustment is not completed until you are sure the blade will stay on when the wheels are turning at high speeds. Check this by replacing the upper and lower wheel covers and pressing the START button to start the motor. After the motor has gained a little speed, press the STOP button and check to see if the blade is tracking near the center of the upper wheel. Do not let the motor accelerate above one-half maximum speed until you are sure the blade is tracking properly. After the new blade is installed and tracking properly, make the necessary guide adjustments and lower the post to within one-eighth of an inch of the working surface. As with other metalworking machines, keep your hands and fingers clear of the cutting blade. Since the sawing and welding operations involve an eye hazard, you must wear goggles or a face shield when you are using a contour metal cutting saw.

Checking and Storing Saw Blades. Before using, saws should be checked for dullness, insufficient set, broken teeth, and faulty welds. If the saw is dull or the set is worn off, the saw should be discarded. If the saw has broken teeth or a faulty weld, the faulty portion should be cut out and the blade rewelded.

Storage of individual saw bands and bulk saw bands is no problem since each machine has a storage cabinet provided with bins to store saw bands, space for accessories, and a place to hang file and polishing bands. Bulk contour saw bands are usually shipped to Air Force shops in 100 foot lengths in special containers. A container has a slot from which any desired length of saw band may be pulled out and cut off. The saw band is then welded into a loop. Once a saw band is welded into a loop it must be folded into smaller loops for storage in the cabinet bins. A loop should be tied with string or wire so that it will not unfold. In folding a saw band for storage, care should be exercised not to kink or bend the band. Kinked and bent bands do not produce the best results in sawing. You should also be careful not to cut or scratch your hands when you fold saw bands.

Procedures for folding are as follows:

1. Hold the band with the teeth up. Span about ⅓ of the circumference of the band with your hands.
2. Turn the palms of your hands up with the thumbs on the outside of the band.
3. Exert thumb pressure toward the center of the loop.
4. Flip band by twisting your thumbs inward and downward to form the loops.

CAUTION: Be certain that there is sufficient space to prevent injury when the band is flipped for folding.

Exercises (276):

1. What factor determines the size of the inserts used on the guide blocks of a contour metal cutting saw?

2. When you inspect the saw blade before operating a contour metal cutting saw, what should you look for?

3. When selecting a saw blade to use in a contour metal cutting saw, what factor concerning the pitch of saw blade must you consider?

4. The tension requirements of the butt welder are determined by what physical feature of the saw blade?

5. Which jaw clamp on the butt welder is released first after releasing the welding lever?

6. Where should you make the necessary cut on a saw blade for making internal cuts?

7. When adjusting the tension on a newly installed saw blade, what is the general rule to follow?

8. How do you know when the saw blade is tracking properly?

9. How high should the post be adjusted from the work table?

10. What type of safety equipment must be used when operating a contour metal cutting saw?

277. Given a work situation, state the proper grinding procedure or proper choice of grinding equipment.

Grinding is the act of dressing, shaping, or finishing surfaces by means of a rotating wheel made up of abrasive substances such as silicon carbide or aluminum oxide. Figure 6-20 shows a type of pedestal grinder commonly found in airframe repair shops for use in sharpening chisels or screwdrivers, grinding drills, or removing excess metal from work pieces. As shown in the illustration, it is usually fitted with both a coarse grain and a fine grain abrasive wheel. The coarse grain wheel is for rough grinding when a considerable amount of metal is to be removed or when a smooth finish is not important. The fine wheel is for sharpening tools, since removing the metal more slowly gives the work a smoother finish and does not usually generate excessive heat that might soften cutting edges. The fine wheel is also more accurate, but accuracy ultimately depends upon the skill of the worker.

Grinding Wheel. A grinding wheel is actually a cutting tool with a large number of cutting edges so arranged that, as they become dull, they break off and new cutting edges take their place. Four factors affect grinding wheels: the kind of abrasive, the size of the abrasive particles, the kind of bond, and the amount of bond.

Silicon carbide and aluminum oxide are the abrasives in most grinding wheels used by the airframe repairman. Silicon carbide is the cutting agent for grinding hard, brittle material, such as cast iron. It is also used in grinding aluminum, brass, bronze, and copper. Aluminum oxide is the cutting agent for grinding steel and other metal of high tensile strength.

The size of the abrasive particles used in grinding wheels is indicated by a number which corresponds to the number of meshes per linear inch in the screen through which the particles will pass. As an example, a No. 30 abrasive will pass through a screen having 30 holes (meshes) per linear inch, but will be retained by a smaller screen having 60 holes per linear inch.

The bond is the material which holds the abrasive particles together in forming the wheel. The kind and amount of bond used determines the hardness or softness of the wheel. The commonly used bonds are the vitrified bond, silicate bond, resinoid bond, rubber, and shellac. Vitrified and silicate bonds are used the most; vitrified bond is used in approximately three-fourths of all grinding wheels. This bonding material forms a very uniform wheel and is not affected by oils, acids, water, heat, or cold. The silicate bond, however, is best suited for grinding edged tools. Resinoid-bonded wheels are for heavy-duty grinding. Rubber-bonded wheels are used when a high

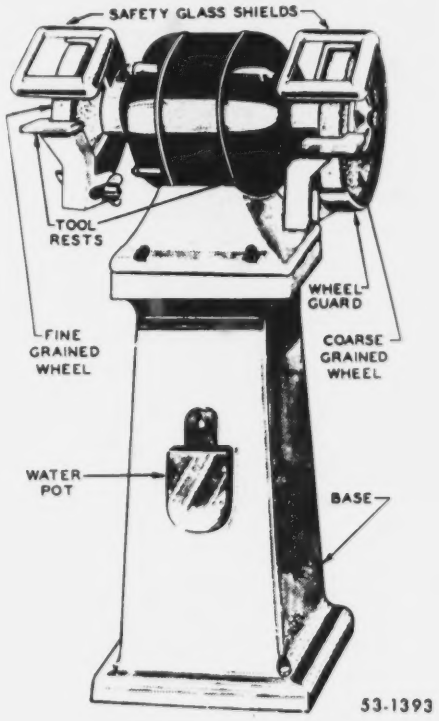

Figure 6-20. Pedestal grinder.

polish is required. Shellac-bonded wheels are used to form grinding materials when a buffed or burnished surface is needed.

Grinding wheels are removable. Grinders are usually so designed that wire brushes, polishing wheels, or buffing wheels can be substituted for abrasive wheels.

Grinding Wheel Markings. Every grinding wheel is specifically identified by a marking system which represents its physical characteristics (abrasive, grain, grade, structure, and bond). Wheel marking is the last operation in the manufacture of a wheel. Identification is done by stencil or small tags. Wheel manufacturers and users have worked out a standard system of wheel marking which consists of a line of six letter and number codes like the example in figure 6-21.

Remember that the identity of markings on two wheels is not a guarantee that both wheels will grind alike. There may be variables in the material so that a wheel could not be labeled according to figure 6-21 into an exact and accurate code. So far, however, this is the best system of coding wheels that is available and is in use today by most grinding wheel manufacturers.

Figure 6-21 illustrates the folowing:

a. Position 1—a letter designating the kind of abrasive grain. A for aluminum oxide and C for silicon carbide, prefixed at the option of the manufacturer by a symbol of his own. This may further modify the abrasive symbol according to his own practices and nomenclature.

b. Position 2—a number denoting grain size, 6 to 600, coarse to fine.

c. Position 3—a letter denoting the grade, A to Z, soft to hard.

d. Position 4—a number denoting structure, 1 to 15, dense to open.

e. Position 5—a letter denoting kind of bond, as follows:

V = vitrified	B = resinoid
S = silicate	E = shellac
R = rubber	O = oxychloride

f. Position 6—a symbol peculiar to each manufacturer, to be used by him for any purpose, typically denoting a modification of the bond.

Maintenance of Grinding Wheels. Before grinding a drill, you should dress the abrasive wheel, if necessary. The terms dressing and truing are frequently confused or carelessly interchanged. The term dressing describes the reconditioning of the grinding surface of a wheel which has lost some of its cutting ability because of glazing or loading up of the bonding material between abrasive particles. Truing, on the other hand, refers to the operation of restoring the grinding wheel to its correct geometrical shape, which is not required as frequently as the dressing operation. The Huntington-type dresser, which consists essentially of a number of circular metal cutters mounted on a spindle in a holder, is the most commonly-used type of dressing tool. Figure 6-22 shows this tool in use. The dulled abrasive grains and any loading of metal or foreign material are being removed so that sharp grains are being presented to the work.

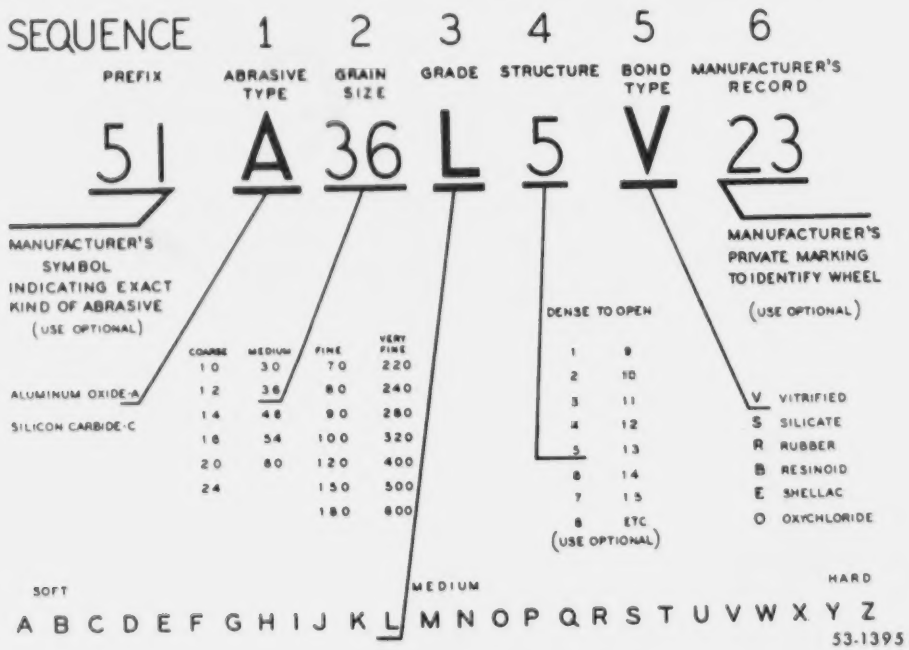
SEQUENCE 1 2 3 4 5 6
PREFIX
ABRASIVE TYPE
GRAIN SIZE
GRADE
STRUCTURE
BOND TYPE
MANUFACTURER'S RECORD
51 A 36 L 5 V 23
MANUFACTURER'S SYMBOL INDICATING EXACT KIND OF ABRASIVE (USE OPTIONAL)
ALUMINUM OXIDE-A
SILICON CARBIDE-C
COARSE 10 12 14 16 20 24
MEDIUM 30 36 46 54 60
FINE 70 80 90 100 120 150 180
VERY FINE 220 240 280 320 400 500 600
DENSE TO OPEN
1 2 3 4 5 6 7 8
9 10 11 12 13 14 15 ETC
(USE OPTIONAL)
MANUFACTURER'S PRIVATE MARKING TO IDENTIFY WHEEL (USE OPTIONAL)
V VITRIFIED
S SILICATE
R RUBBER
B RESINOID
E SHELLAC
O OXYCHLORIDE
SOFT
MEDIUM
HARD
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
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Figure 6-21. Standard Norton grinding wheel markings.

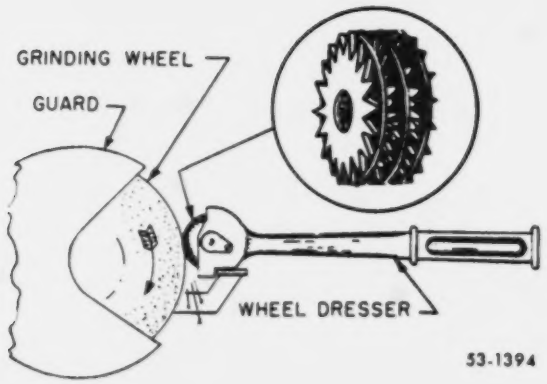

Figure 6-22. Huntington grinding wheel dresser.

To dress an abrasive wheel, proceed as follows:

a. Adjust the grinder tool rest to approximately center height and far enough from the wheel to permit the legs of the dresser to fit over the edge of the tool rest when the handle of the dresser is held horizontal with the cutters touching the wheel.

b. Place the dresser on the tool rest with the handle down to allow a slight space between the cutters and the abrasive wheel.

c. Start the grinder and allow it to come up to operating speed.

d. Raise the handle of the dresser to make contact with the wheel.

e. Hold the dresser firmly against the rest and move it in a steady motion back and forth across the face of the wheel.

f. Raise the handle of the dresser slightly for successive depths of cuts.

Excessive sparking is caused by the cutters riding too lightly on the wheel face. This causes rapid cutter wear and can be corrected by applying more pressure against the wheel face.

Precautions. As an airframe repairman, you must know the correct cutting edge angle of a tool before attempting to sharpen it. After determining the correct cutting angle, turn on the grinder switch and hold the work firmly at the correct angle on the tool rest provided. Feed the tool into the wheel with just enough pressure to remove the proper amount of metal without generating too much heat.

Grinders are very hazardous; be careful when operating them. You must not use the work rest when it is more than ⅛ inch from the grinding wheel. When starting a grinder, stand to the side until it attains operating speed. This protects you if a defective wheel disintegrates. If the grinder chatters or vibrates excessively, something is wrong; turn the power off at once.

As a rule, it is not good practice to grind work on the side of an abrasive wheel. When an abrasive wheel becomes worn, its cutting efficiency is reduced because surface speed decreases. Discard such a worn wheel and install a new one.

Before installing a new wheel, inspect it. Wheels may become damaged from not being stored properly. Immediately upon receipt, all wheels should be closely inspected to make sure that they have not been damaged. Even after they have been in storage, every wheel should be closely inspected and rung for cracks. Small wheels may be checked for imperfections by suspending them on one finger and tapping them gently with a light instrument, such as the handle of a screwdriver. Very large wheels may be struck with a wooden mallet. If a clear ring is not obtained, the wheel should be examined for cracks. Cracked wheels should be discarded. All wheels do not produce the same tone when rung; nor does a low tone necessarily signify a cracked wheel, since wheels are often filled with various resins and greases to modify their cutting action. This deadens the tone of the wheel. Vitrified and silicate wheels emit a clear metallic ring. Organic bonded wheels, such as resinoid, rubber, and shellac, give a less clear tone, but the sound of a cracked wheel will be perfectly apparent.

Before using a grinder, make sure the abrasive wheels are held firmly on the spindles by the flange nuts. If an abrasive wheel were to come off or become loose, it could ruin the grinder and seriously injure the operator. Another safety hazard is loose tool rests. We mentioned earlier the operating distance of the rest, but if the rest is loose, it could cause the tool or piece of work to be *grabbed* by the abrasive wheel and cause the operator's hand to come in contact with the wheel. Severe wounds may result.

Always wear goggles, even if the machine is equipped with face guards. The only sure way to protect your eyes from the fine pieces of steel is to use goggles that fit firmly against your face and nose. Goggles that do not fit properly should be exchanged for ones that do.

Before starting the machine, inspect the wheel for cracks. A cracked abrasive wheel is likely to fly apart when running at high speed. Never use a grinder unless it is equipped with wheel guards.

Exercises (277):

1. If you have to grind cast iron materials, which type of grinding wheel is recommended?

2. If the part being ground requires a highly polished surface, which type of grinding wheel would you select?

3. What must you do before grinding a drill on a grinding wheel?

4. When you have completed the dressing operation, how far from the grinding wheel should you adjust the tool rest?

5. What should you do to cracked grinding wheels?

6. What safety equipment must be worn when using a grinding wheel?

6-3. Mechanical Punches

Sometimes you must cut small holes in metal parts under conditions which make the use of a hole saw or some other type hole cutter impractical. Small holes such as relief holes, lightening holes, and large diameter fastener holes are examples of such holes. Different types of mechanical punches, like the rotary punch and Whitney punch, provide you the means of cutting small holes quickly and easily.

278. Describe specified operating procedures of rotary punches and Whitney punches.

Rotary Punch. This large punch press is used in the airframe repair shop to punch holes in metal parts. It can also be used for cutting radiuses in corners and for making washers. The rotary punch press shown in figure 6-23 is found in most airframe repair shops. It is composed of two cylindrical turrets, one mounted over the other and supported by the frame. Both turrets are synchronized so that they rotate together, and the index pins maintain correct alignment at all times. To release the index pins from their locking position, the lever, which is located on the right side of the machine, is rotated through a 180° arc. This action withdraws the index pins from the tapered holes and allows you to turn the turrets to any size punch desired.

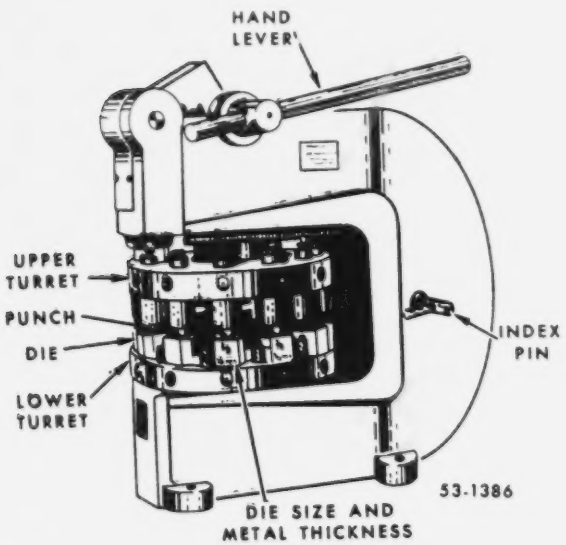

Figure 6-23. Rotary punch.

To operate this rotary punch, place the metal between the die and punch. Then the hand lever, on the top right side of the machine, is pulled towards you. This forces the punch through the metal. When the lever is returned to its original position, the metal is stripped off the punch.

Stamped on the front of each die holder is the diameter of the punch and its maximum capacity for punching mild steel. Each punch is made with a point which can be placed in the center punch mark. This point assures you of the definite location to be pierced.

To accurately align the punch and die, you must determine whether or not an adjustment is necessary by punching through several thicknesses of stiff paper. This shows which side of the die has the greatest clearance. If the cut is uneven, loosen the lockscrews and tap the die toward the side with the least clearance. When the paper is cut evenly all around, tighten the punch securely with the lockscrews which are located between each set of dies.

Preventive maintenance for the rotary punch consists mainly of keeping it cleaned, adequately lubricated, and properly adjusted. The rotary punch illustrated in figure 6-23 is periodically inspected to see that the index pin works freely and locks the upper and lower turrets easily. If necessary, clean and oil the index pin and align holes in the turrets. Inspect each punch and die to see if it lowers and raises freely when the hand lever is pulled forward. Cleaning and oiling are necessary for any that stick. For thorough cleaning, you must remove a sticking die or punch. Then clean the punch and its sleeve and lightly coat them with oil before reassembling. Inspect the hand lever and connecting linkage for cleanliness and freedom of operation; if necessary, clean and oil the moving parts. Inspect each punch for proper alignment with its corresponding die. Do this, as mentioned earlier, by punching several thicknesses of stiff paper. After inspection, wipe off all excess oil, clean all painted surfaces with a dry rag or a rag moistened with soap and water, and wipe all unpainted surfaces with a slightly oiled rag.

The principal safety precaution to observe when operating the rotary punch press is to keep your fingers away from the punch and die, and return the hand lever to the full UP position after each operation has been completed.

Whitney Punch. The leverage-type hand punch has largely taken the place of hollow hand punches. The

Whitney punch has interchangeable dies for piercing holes in metal. The Whitney punch, shown in figure 6-24, is used to punch light-gage metal and is available with dies ranging in size from 1/16 to 9/32 inch. When making holes in exact locations, set the centering point in the center punch mark.

You will find that the Whitney punch pierces holes much faster in light-gage metal than it is possible to do with twist drills. When changing punches and dies, be sure to match the sizes. A punch that is too large for a die will damage the cutting edges, and one that is too small will pierce the hole but dimple the material.

These leverage-type punches are handy tools around the airframe repair shop, since they afford you a simple means of punching clean holes.

There are a number of hand lever punches other than the Whitney illustrated in figure 6-24. The one in your shop may be different. However, they all work pretty much alike. When working with these punches, keep the working parts well lubricated to insure ease of working.

Most punches have an attached gage which consists of a guide and an adjustable scale. The scale graduation on the guide mark indicates the depth of the throat in inches—that is, the distance from the edge of the sheet stock to the center of the hole. This gage is not generally used, because you should first use a center punch to mark the position of the holes to be punched. Then you can easily feel this punch mark with the hand punch centering point. Never use a punch on material beyond the capacity of that particular punch.

Changing dies in a leverage-type hand punch is a relatively simple matter. The bottom die is made with threads cut around the outside. This die screws into the lower tip of the throat jaws by means of a slot. By placing a screwdriver in this slot, you can move the die in or out as the need arises. The punch can be removed by taking out the pin or screw located just forward of the lower handle; then, by pushing the punch holder forward, you easily remove the punch die. To replace the punch, reverse the procedure. The basic handicap of the leverage-type Whitney punch is that the punch has a short throat and can only be used when the hole locations are near the edge of the material.

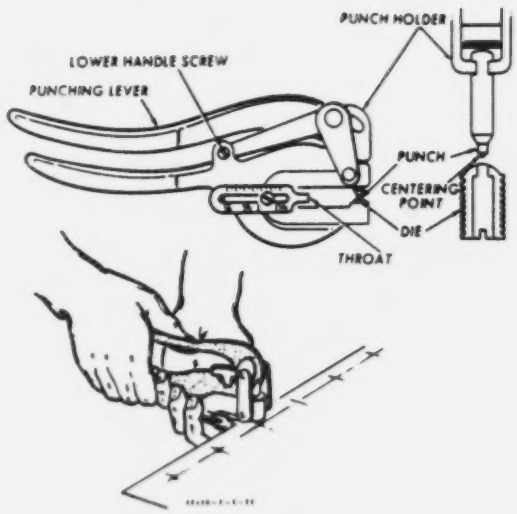

Figure 6-24. Whitney punch.

Exercises (278):

1. Why is it recommended that you center punch holes to be punched on a rotary punch?

2. What procedure can you use to check the alignment of the dies on a rotary punch?

3. What must you remember when installing dies in a Whitney punch?

4. Why are you not likely to use the depth gage on the Whitney punch?

5. What is the cause if the hole punched with a Whitney punch is dimpled?

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Department of the Air Force Publications

TO 1-1A-1, *General Manual for Structural Repair.*
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TO 32-1-151, *Hand, Measuring and Power Tools.*
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TO 32-1-201, *Measuring Tools.*
TO 34C1-8-6-24, *Contour Metal Sawing, Filing, and Polishing Machine.*
TO 34G1-1-113, *Forming and Flanging Machine.*

NOTE: None of the items listed in the bibliography above are available through ECI. If you cannot borrow them from local sources, such as your base library or local library, you may request one item at a time on a loan basis from the AU Library, Maxwell AFB AL 36112, ATTN: ECI Bibliographic Assistant. However, the AU Library generally lends only *books* and a limited number of *AFMs*. TOs, classified publications, and other types of publications are *not* available. Refer to current indexes for the latest revisions of and changes to the official publications listed in the bibliography.

Answers for Exercises

CHAPTER 1

Reference:

200 - 1. Because the repairs that you make can directly affect the flight characteristics of an aircraft.

200 - 2. (1) Gravity is the force which tends to hold the aircraft to the ground. (2) Thrust is the forward force produced by the aircraft's engines. (3) Drag is the resistance of air against the aircraft surfaces. (4) Lift is the force which overcomes the pull of gravity and permits the aircraft to leave the ground.

200 - 3. An airfoil is any surface built to obtain a reaction upon itself from the air through which it passes.

200 - 4. Angle of attack, speed of the airfoil, air density, and shape of the airfoil determine the amount of lift and drag an airfoil develops.

201 - 1. Truss, monocoque, and semimonocoque.

201 - 2. Semimonocoque is used on present day aircraft because it overcomes the strength-weight problem of the monocoque type construction.

201 - 3. Formers are the lightest cross-sectional members of the fuselage; bulkheads are the heaviest cross-sectional members used to carry concentrated stress loads.

201 - 4. Longerons are the main lengthwise members of the fuselage bearing most of the load; stringers are the secondary lengthwise member.

201 - 5. An extruded angle stringer is produced by forcing hot metal through a die in which there is an opening corresponding to the desired cross-section shape of the stringer. The extruded stringer has a high strength-to-weight ratio.

201 - 6. Constant gage metal, machine milled, and chem-milled.

202 - 1. Spar.

202 - 2. Cantilever design.

202 - 3. Multispar.

202 - 4. Web and cap strips.

202 - 5. Ribs give the wing its shape and transmit the load from the skin to the spar.

202 - 6. In areas where the greatest stresses are imposed.

202 - 7. To support high compressive loads or to maintain a shape.

202 - 8. The leading edge section of the wing streamlines the forward portion of the wing. The center section is the main structural portion of the wing. The trailing edge section is where flight control are attached.

202 - 9. They are used to streamline areas and reduce drag.

203 - 1. Stabilize the aircraft.

203 - 2. The *slab* combines the functions of both a stabilizer and control surface where the *flying tail* has movement, and a control surface is also attached.

203 - 3. The vertical stabilizer controls the aircraft about its vertical axis and the horizontal stabilizer controls the aircraft around the aircraft's lateral axes.

203 - 4. Rudder and elevators.

203 - 5. The stronger spar in the stabilizer is placed *behind* the others; the attaching of control surfaces requires the strength farther back.

204 - 1. Trailing edge of the horizontal stabilizer; they control pitch (movement about the lateral axis).

204 - 2. Trailing edge of the vertical stabilizer; it provides directional control around the vertical axis.

204 - 3. Ailerons; they furnish control about the longitudinal axis for banking.

204 - 4. To disturb the smooth airflow and increase the effectiveness of ailerons.

204 - 5. Aid in the movement of the primary control surfaces.

204 - 6. Trailing edge of the primary control surfaces.

204 - 7. Flaps are located on the inboard section of the wing. They are used to increase lift and drag for landing and takeoff in order to shorten the landing or take off roll.

204 - 8.
1. Wing.
2. Fuselage.
3. Aileron.
4. Flap.
5. Horizontal stabilizer.
6. Engine nacelle.
7. Rudder.
8. Vertical stabilizer.
9. Elevator.
10. Trim tab.
11. Balance tab.

CHAPTER 2

205 - 1. b.
205 - 2. g.
205 - 3. e.
205 - 4. c.
205 - 5. j.
205 - 6. f.
205 - 7. d.
205 - 8. a.
205 - 9. h.
205 - 10. i.

206 - 1. Strength/weight ratio.

206 - 2. (1) Use a better grade of base metal; (2) coat the surface with a thin coat of paint, tin, chromium, aluminum or cadmium; (3) use the electrochemical process called anodizing.

206 - 3. Workability.

206 - 4. The resistance a part has to failure caused by repeated reversal of applied loads.

206 - 5. The ability of a metal to be formed, bent, or machined to required shapes.

206 - 6. Welding.

206 - 7. Cold-working increases the tensile strength of metal.

206 - 8. Yes—Shear strength is approximately 60 percent of the tensile strength.

207 - 1. Tensile stress is the force per unit area tending to stretch a structural member.
207 - 2. Sideways (lateral).
207 - 3. The greatest stress occurs along the neutral axis of the metal being bent.
207 - 4. Compression.
207 - 5. Only stresses of shear are developed when a part is twisted; both shear and compressive stresses are developed when a piece of metal is bent.
207 - 6. Compression.

208 - 1. By cold-working.
208 - 2. Aluminum is about one-third the weight of iron, slightly heavier than magnesium and somewhat lighter than titanium.
208 - 3. Because of its high strength/weight ratio and its comparative ease of fabrication.
208 - 4. Copper.
208 - 5. Because of the oxidation formed on the surface when the metal is heated.
208 - 6. Whether the physical properties can be changed by heat-treating after the part is casted.
208 - 7. The method by which the molten metal flows into mold or die.
208 - 8. Heat-treatable and non-heat-treatable.
208 - 9. The thickness of the sheet.

209 - 1. Major alloying element.
209 - 2. Strain-hardened (cold-worked).
209 - 3. Solution heat-treatment and artificial aging.
209 - 4. Degree of strain hardening—actual temper.
209 - 5. Printed as a decimal fraction of an inch in thousandths.
209 - 6. Maroon, (space), blue, maroon, white, (space), yellow, olive drab.
209 - 7. Heat-treatable aluminum from non-heat-treatable aluminum.
209 - 8. To identify (differentiate between), 7075 and 2024 aluminum.
209 - 9. (1) Alloy designator.
(2) Temper indicator.
(3) Thickness.
(4) Federal specifications.
209 - 10. Refers to the document which establishes how much materials are incorporated into production of a particular alloy.

210 - 1. In structural parts of the aircraft where strength is required.
210 - 2. Alloy 2017.
210 - 3. Alloy 2014.
210 - 4. Alloy 6061.
210 - 5. The main alloy element is zinc.
210 - 6. They do not respond to any heat-treatment other than the annealing (softening) process.
210 - 7. Alloy 5052.

211 - 1. Because of its corrosion resistance, moderate strength, and light weight.
211 - 2. Because of the high cost of titanium.
211 - 3. Oxygen diffuses into the metal and produces embrittlement and corrosion.
211 - 4. Because of the natural oxide film on the surface.
211 - 5. Alpha.
211 - 6. It assures excellent strength characteristics and oxidation resistance at high temperatures.
211 - 7. Beta.

212 - 1. TO 1-1A-9.
212 - 2. Spark test and glass test.
212 - 3. Printed as a decimal fraction of an inch in thousandths.
212 - 4. The 4 indicates the percent of aluminum alloyed. The 6 indicates the percent of vanadium alloyed.

213 - 1. Magnesium is the lightest of structural metals; its alloys have a high strength-to-weight ratio.
213 - 2. Galvanic corrosion (dissimilar metals).
213 - 3. The rare earth-metal binary group and Mg-Th binary group.
213 - 4. Magnesium can be worked by all known methods, but it is especially well adapted to the extrusion process.
213 - 5. Because of their desirable structural behavior at "normal" temperatures (up to 300° F).
213 - 6. Because they are radioactive to a small degree.

214 - 1. Stamped on the part itself.
214 - 2. Intervals of 2 feet or less.
214 - 3. (1) "HZ" indicates that thorium and zinc are the two principal alloying elements.
(2) "32" indicates the percentages of the thorium (3 percent) and zinc (2 percent).
(3) "A" indicates that this is the first alloy standardized with 3 percent thorium and 2 percent zinc.
214 - 4. Magnesium.
214 - 5. To expose the base metal.
214 - 6. Probably aluminum.

215 - 1. "Ferrous" means that a metal has more iron than any other element.
215 - 2. A metal is considered nonferrous if it contains more of any other metal than it does of iron.
215 - 3. a. Nonferrous.
b. Nonferrous.
c. Ferrous.
d. Ferrous.
e. Ferrous.
f. Nonferrous.
g. Nonferrous.
215 - 4. Refers to a steel that also contains one or more elements in addition to carbon and iron.

216 - 1. The first number indicates the type of steel, the second number—and sometimes the third—usually indicates the approximate percentage of the principle alloying element. The last two numbers—sometimes three—indicate the approximate carbon content in one-hundredths of 1 percent (0.01 percent).
216 - 2. The AISI coding system uses a prefix indicating the process used in the manufacture of the metal.
216 - 3. For procurement purposes.
216 - 4. Yellow, black, and white.
216 - 5. Use a sample piece, to compare the sparks.
216 - 6. Nickel-base alloys (inconel) from iron-base alloys (18-8 stainless steel).
216 - 7. Nitric acid attacks hardened steel very rapidly; it attacks stainless steel very slowly.

217 - 1. Low carbon—0.10 to 0.30 percent carbon, medium—0.31 to 0.50 percent carbon, high carbon—0.51 to 1.05 percent carbon.
217 - 2. Nickel-cobalt base alloys.
217 - 3. Because heating will anneal and remove required strength, which cannot be replaced by any shop working procedure.
217 - 4. Aluminum.
217 - 5. Toughness and hardness.
217 - 6. Cold-working.
217 - 7. Surface condition and composition of the metal, and temperature and concentration of the corrosive agent.
217 - 8. Welding.
217 - 9. Because of expansion and limited heat conductivity.
217 - 10. Resistance to damage from prolonged exposure to high temperature.

218 - 1. Ductility and malleability.
218 - 2. Eventual cracking or breaking.
218 - 3. Decreased—cold-working is the only way the properties of nontreatable aluminum alloys can be increased.

218 - 4. Any process which involves controlling the heating and cooling of metals to develop certain desirable characteristics is called heat-treatment.
218 - 5. Complicated parts and assemblies.
218 - 6. Seven seconds.
218 - 7. As little as 10° under the specified temperature may affect either the physical or corrosion-resistant properties, or both.
218 - 8. Removal of the effects of cold-working and prior heat-treating processes.
218 - 9. For less severe forming operations.
218 - 10. Alclad parts should be heated as quickly and carefully as possible, to prevent destroying the corrosion resistant of the surface coating of pure aluminum.

219 - 1. Overheating, oversoaking, overaging, reheat-treatment, undersoaking, and underheating.
219 - 2. A part will warp when entered into the quenching medium at an angle or if it is a large sheet.
219 - 3. Too slow of a cooling rate causes the alloying elements to collect at the grain boundaries which causes intergranular corrosion.
219 - 4. a. 5, 1.
b. 3, 4.
c. 1.
d. 3, 4.5.
e. 2.

220 - 1. Water.
220 - 2. Aging improves strength and ductility by causing the partial decomposition of the supersaturated beta phase retained from quenching.
220 - 3. Stress relieving; annealing; and solution treating, quenching, and aging.
220 - 4. Stress relieving is done at approximately 600° F. below recrystallization temperature.
220 - 5. Strength and ductility in titanium alloys is produced by the process of solution treating, quenching, and aging; the aging phase is the part of the process that finally fixes these two characteristics.
220 - 6. Titanium alloys are stress relieved to remove residual stresses developed during fabrication procedures.

221 - 1. The soaking period is determined by the composition of the alloy.
221 - 2. Adding silicon, titanium, aluminum, copper or magnesium increases the alloy's response to age-hardening in nickel alloys.
221 - 3. Stress-relieving is reserved for those alloys with compositions which do not harden as a result of heat-treating.
221 - 4. Fast quenching in water results in less scaling from the dead soft annealing temperature.
221 - 5. The precipitation of submicroscopic particles throughout the grains when age-hardening is done.
221 - 6. Between 1300° and 2200° F.
221 - 7. Below.
221 - 8. Solution heat-treating and age-hardening can be performed from the hot- or cold-worked conditions as well as from the soft condition.

222 - 1. The additional spiral twist gives more worm action or force to the drill, causing it to cut or feed faster and is helpful in removing chips, especially in deep hole drilling operations.
222 - 2. When drilling of ¼-inch depth or more.
222 - 3. 47°.
222 - 4. 0.005 - 0.015 inch.
222 - 5. By making sure the holes are sufficiently undersize.
222 - 6. They have a tendency to crack in the vicinity of the cut.
222 - 7. The spacing of the teeth should be as coarse as is consistent with the thickness of the material being sawed.
222 - 8. Quiet smooth cutting saws usually produce smooth burnished surfaces accompanied by excessive heat and consequently decreased blade life.
222 - 9. Wavy set type.
222 - 10. To overcome clogging problem.

223 - 1. Overallowance is the material added to the final dimension in shearing, which is later sanded off. (It is sanded off before forming to prevent stress risers that could otherwise cause the part to tear during forming operations.)
223 - 2. Material thickness.
223 - 3. Parallel to the sheet surface.
223 - 4. Discoloration totaling nor more than ½ inch in any 6-inch increment of edge length, provided that the discoloration does not extend more than ¼ inch back from the edge.
223 - 5. Poor surface finish, high residual tensile stresses, and low grinding ratios.
223 - 6. By employing the proper type wheels at low wheel speed and feeds, and by flooding the grinding area with an inhibitor or purging type of cutting fluid.
223 - 7. Hardening of the material.
223 - 8. Short, two-fluted, high speed twist drills ground to a 135° split point.
223 - 9. Blended out using abrasive sheet or emery cloth of No. 120 grit or finer.
223 - 10. Water-soluble coolants.

224 - 1. 3 to 5 percent of the sheet thickness.
224 - 2. 6 teeth per inch.
224 - 3. The drill has a 70° to 118° point angle, 10° to 30° helix angle, 120° to 135° chisel edge angle, and 12° relief angle.
224 - 4. Because of the danger of producing sparks with iron, steel, or other metals.
224 - 5. 5 metal thicknesses larger (12-7).
224 - 6. 450° F.
224 - 7. To facilitate dust collection.
224 - 8. One-sixth of those for mild steel.
224 - 9. Sawing.
224 - 10. To improve the characteristic rough flaky edge of magnesium which has been sheared.

225 - 1. High speed twist drills.
225 - 2. To prevent hardening of the metal and excessive drill damage from heat.
225 - 3. By using adequate lubrication or coolant.
225 - 4. They are used to alleviate the chatter and difficult chip removal associated with the straight fluted reamers.
225 - 5. A high speed steel saw blade with approximately 32 teeth per inch for light work and approximately 24 teeth per inch for heavy work.
225 - 6. Type of steel and temper condition.
225 - 7. Carburization and pitting of the surface will result.
225 - 8. Thickness.
225 - 9. Areas where parts are subjected to flexing or to concentrated stresses caused by possible fatigue or stress-corrosion failure.
225 - 10. Lubricate with lightweight engine oil or soap at regular intervals.

226 - 1. Metal anode—something that corrodes (the metal).
Cathode—cause.
Electrolyte—continuous liquid path.
Conductor—provides for metal-to-metal contact.
226 - 2. The elimination of any one of the four conditions will automatically stop corrosion.
226 - 3. Corrosion is generally accelerated by high temperatures.
226 - 4. Because of the possible variations in their composition, particularly if the sections are heat-treated during fabrication.
226 - 5. Proper maintenance procedures.
226 - 6. The corrosion shifts to the non-corrosion-resistant part and the corrosion increases in severity.
226 - 7. Improper heat-treatment results in undesired hardness and makes the material subject to intergranular chemical reaction.
226 - 8. Electrolyte.

227 - 1. Uniform etch.
227 - 2. Pitting.
227 - 3. When sufficiently wide potential differences exist between the anodic grain boundaries and the cathodic grains, rapid and concentrated intergranular corrosion occurs.
227 - 4. Exfoliation.
227 - 5. By a buildup of corrosion at the joints between the metals.
227 - 6. Combination of corrosion and cyclic stresses.

228 - 1. Most of them are areas where moisture collects.
228 - 2. Corrosion products appearing at crevices through which the corrosive agents enter and buckling of the skin.
228 - 3. Beginning at the tip, inspect the leading edge, the trailing edge and finally the lower surface.
228 - 4. Hinge-pinhole.
228 - 5. Documentation.
228 - 6. TO 1-1-2, *Corrosion Control and Treatment for Aerospace Equipment.*

229 - 1. To reduce galvanic corrosion of the magnesium alloys and also reduce simultaneous corrosion of the aluminum.
229 - 2. The specific -3 for the aircraft being repaired.
229 - 3. Protect parts during forming, cutting, etc. operations; use vise jaw protectors when filing; mark layout lines with a pencil only, and use proper storage procedures.
229 - 4. Carbon combines with titanium at high temperatures and weakens the materials which in turn leads to cracks along the layout line.
229 - 5. Individually, with 15-pound paper between each sheet.
229 - 6. Any time two pieces of aluminum alloy are fastened together.
229 - 7. When magnesium is in contact with a different type metal.

230 - 1. Maintaining original strength requirements.
230 - 2. Different manufacturers design structural member to meet various load requirements for specific aircraft.
230 - 3. Thickness.
230 - 4. Increase the thickness of the doubler or backing plate.
230 - 5. When making repairs on control surfaces, because of the balance problems involved.
230 - 6. T-4.
230 - 7. Material composition, temper condition, and thickness.

CHAPTER 3

231 - 1. Clamp pliers.
231 - 2. Half-roundnose pliers.
231 - 3. The jaws are square, fairly deep, and usually well matched.
231 - 4. Because the opening of the jaws can be increased.
231 - 5. This would damage both the jaw serrations and the item being turned.
231 - 6. Do not overheat the plier jaw, causing loss of temper.

232 - 1. Box-end wrench.
232 - 2. Socket wrench (faster than open-end).
232 - 3. Spanner wrench.
232 - 4. Adjustable wrench.
232 - 5. Always use a wrench that fits the job.
232 - 6. Clean with solvent.

233 - 1. The tip is straight on common type screwdrivers; phillips screwdrivers have a 4-way slotted tip.
233 - 2. The tips on the reed and prince is pointed.
233 - 3. In tight places.
233 - 4. Ratchet screwdriver.
233 - 5. By placing a tightly fitted adjustable or open end wrench to the flat side of the screwdriver tip.
233 - 6. First try to tighten the screw by a slight turn clockwise. Then turn the screwdriver counterclockwise, and keep tightening and loosening the screw alternately until it turns freely for removal.
233 - 7. The point of the screwdriver may break or slip, mutilating the screw slot or the work.
233 - 8. The work should be placed in a vise or on a solid surface that will bear the pressure of the screwdriver.
233 - 9. Without the use of a proper fixture, the original angles and bevels are destroyed, throwing the screwdriver out of balance making it unsafe to use.

234 - 1. 8-ounce ballpeen hammer.
234 - 2. When you must protect the surface of the work.
234 - 3. Setting down, clenching or tucking in the edges of sheet metal.
234 - 4. Planishing hammer.
234 - 5. Mallets.

235 - 1. a. Prick punch.
b. Center punch.
c. Pin punch.
d. Starting punch.
e. Drift punch.
f. Transfer punch.
g. Hollow punch.

236 - 1. Measurement and straightedge drawing or checking.
236 - 2. Tape.
236 - 3. Mark cut lines on metal.
236 - 4. When checking distances between two points or when transferring and comparing measurements.
236 - 5. When drawing lines other than 45°.
236 - 6. Because of the included angle of the point of the center punch, which is equal to slightly more than the included angle of a standard ground twist drill.

237 - 1. 0.224 inch.
237 - 2. 0.025 inch.
237 - 3. A ratchet is used to apply pressure for measuring, and slips if the pressure is great enough to damage the micrometer.
237 - 4. 0.700.

238 - 1. Thickness gage.
238 - 2. Sheet metal and wire gage.
238 - 3. (a) A twist drill gage, (b) a drill grinding gage.
238 - 4. A thread gage.
238 - 5. A radius gage.

239 - 1. Aviation snips.
239 - 2. Straight Snips.
239 - 3. To allow seeing the cutting line.
239 - 4. Top blade.
239 - 5. Filing and grinding.

240 - 1. 1. b.
2. f.
3. d.
4. c.
5. a.
6. e.
240 - 2. Single cut.
240 - 3. When filing very soft materials.
240 - 4. When a finer surface is required.
240 - 5. Oil or chalk.
240 - 6. Always use a file handle.
240 - 7. Because the cutting teeth slant forward and the pressure on the back stake will probably break them off.
240 - 8. Near to the vise jaws to prevent vibration and, if the surface is straight, parallel to the top of the vise.

241 - 1. Cutting sheet metal, chipping, cutting heads off screws, and cutting flat stock.
241 - 2. Pressing too hard against the wheel and allowing too much heat to generate.

241 - 3. To cut V-shaped grooves.
241 - 4. b. Diamond.
d. Cape.
f. Flat.

242 - 1. All-hard blade with 18 teeth per inch.
242 - 2. 32 teeth per inch.
242 - 3. To allow clearance for the rest of the blade.
242 - 4. 24 teeth per inch.
242 - 5. Clamp the material in a vise, providing as much bearing surface as possible, so that the greatest number of teeth on the blade will be engaged.
242 - 6. Foreward.
242 - 7. Alternate, undulated (wave), raker.

CHAPTER 4

243 - 1. ½, ½, ½.
243 - 2. ½, 9/64.
243 - 3. 1 1/4, 1 3/64.
243 - 4. 1/4, 1/32.
243 - 5. 1/64, 9/20.
243 - 6. ¾, 1½.
243 - 7. .09375, .75.

244 - 1. 352.7, 808.099.
244 - 2. 683.17, 1.70001.
244 - 3. 3, 0.328125.
244 - 4. 8, 0.3.
244 - 5. ¼, ⅜.

245 - 1. The metric system.
245 - 2. Units are in multiples of 10.
245 - 3. France.
245 - 4. Charles-Maurice Talleyrand.
245 - 5. 1975.
245 - 6. Problems are created in trade and communications.
245 - 7. 1980.

246 - 1. Length-meters, weight-grams, volume-liters.
246 - 2. Basic roots and prefixes.
246 - 3. Prefixes.
246 - 4. Convenience of the scale (0° to 100°).
246 - 5. 1. e.
2. a.
3. b.
4. c.
5. f.
6. d.

246 - 6 1. Kilogram, (c).
2. Celsius, (f).
3. Metric ton, (e).
4. Centiliter, (b).
5. Milimeter.
6. Milligram, (d).

247 - 1. Length.
247 - 2. Width.
247 - 3. Height.
247 - 4. Depth.

248 - 1 a. 4
b. 1
c. 2
d. 3
e. 5
248 - 2. Visible outlines.
248 - 3. Invisible outlines.
248 - 4. Dimension lines have a break in the middle, for inserting the number indicating size, and have arrowheads on each end. Extension lines are light solid lines.
248 - 5. They indicate that two separate parts meet at a given point, or that a cutting plane intersects part of the object.

249 - 1. Detail or size, position or location, and overall.
249 - 2. Position dimension.
249 - 3. Detail dimension.
249 - 4. Overall dimension.
249 - 5. So that they can be read from the bottom of a drawing.

250 - 1. Technical order.
250 - 2. Envelope.
250 - 3. Installation.
250 - 4. Detail.
250 - 5. Design control.
250 - 6. Production or manufacturing.
250 - 7. Assembly.
250 - 8. Sectional.
250 - 9. Technical order.

251 - 1. The lower right-hand corner. This is true of all drawings prepared according to military standards.)
251 - 2. Quick identification of a blueprint.
251 - 3. Left-hand side.
251 - 4. It indicates the size of the drawing as compared with the actual size of the part.
251 - 5. They are there to help you locate a particular point on the drawing.
251 - 6. The type of finish on the surface.
251 - 7. Unilateral, bilateral.
251 - 8. ⅜ indicates diameter.
15 indicates the number of threads per inch.
NC indicates the thread series (NC = National Coarse).
2 indicates the class of thread and tolerance, commonly called fit.
251 - 9. Never measure the dimensions on the blueprint.
251 - 10. They are used to identify right- and left-hand parts.

252 - 1. Large amounts of information can be stored on a single sheet.
252 - 2. A special viewer is required.
252 - 3. Make an enlarged photographic reproduction.
252 - 4. Some originals must be modified and kept current for a long period of time.

253 - 1. Two dimensions—length and width.
253 - 2. The shape of the object.
253 - 3. Three views.
253 - 4. Auxiliary.
253 - 5. Because you are looking at the top, bottom, or side of an object at a 90° to the surface looking directly at it. You "see" the curved surface only when you look at its edge.

254 - 1. Three views.
254 - 2. Top, front, and side.
254 - 3. Top view above the front view and side view to the right of the front view on the same plane.
254 - 4. Simple objects.
254 - 5. Objects with one irregular face.
254 - 6. The object is placed parallel to the plane of projection and projected to that plane by oblique lines.

255 - 1. Geometric construction is the construction and layout of points, lines, and figures using only a straightedge and compass. (Naturally, you need something like a pencil or scribe to mark the lines, and you can use a pair of dividers as a scribing compass.)
255 - 2. List any five of the following:
a. Bisecting a line.
b. Bisecting arcs.
c. Bisecting angles.
d. Erecting a perpendicular from a point off a line.
e. Erecting a perpendicular from a point on a line.
f. Dividing a line into equal parts.
g. Constructing lines parallel to a line.
h. Constructing arcs tangent to intersecting lines.
i. Constructing an arc of a given radius within a right angle.

256 - 1. The degree of bend refers to the formed position of the material after forming. Radius of bend is the bend in the metal, measured on the inside of the curved material.
256 - 2. Because the forces of stretching and shrinking have no effect on it.
256 - 3. Mold point is the point of intersection of the lines extending from the outside surfaces. The mold point is used in measuring overall dimensions.
256 - 4. To determine the dimensions of the flats.
256 - 5. Two.

257 - 1. .323.
257 - 2. .214.
257 - 3. .126.
257 - 4. .326.
257 - 5. a. 1.124.
b. .924.

CHAPTER 5

258 - 1. Bumping means forming or shaping metal by hammering or pounding.
258 - 2. To curve metal.
258 - 3. Force the metal outward toward the edges by hammering on areas supported by an anvil or similar base support.
258 - 4. Compressing or forcing material into a smaller area.

259 - 1. Ash and maple.
259 - 2. Shrinking blocks.
259 - 3. Sandbags.
259 - 4. a. Conductor stake.
b. Double-seaming stake (simple).
c. Candle mold stake.
d. Roundhead stake.
e. Hatchet stake.
259 - 5. Utility bench vise.

260 - 1. Always strike directly above the V in the block.
260 - 2. Make a full-sized, accurate pattern with which you can check the accuracy of the part being formed.
260 - 3. Lack of springback.
260 - 4. Because it is faster, easier, and affects the metal less.
260 - 5. Upward.
260 - 6. This keeps the vertical flange from bending outward.
260 - 7. When the curve in the formed angle is to be quite sharp or when the flanges of the angle are rather broad.
260 - 8. The thickness and hardness of the metal.
260 - 9. To reduce the difficulty in working out the crimps.
260 - 10. Between the original crimps.

261 - 1. Shrink it.
261 - 2. Wooden form blocks.
261 - 3. Start hammering near the center and work the flange down gradually toward each end.
261 - 4. It determines the kind of hammer you use. For form blocks made of metal, use a soft-faced mallet; for form blocks made of hardwood, use a metal planishing hammer.
261 - 5. When shrinking you start at the center, and when you are stretching you start at the ends, working toward the center.
261 - 6. Because the metal is made to occupy less space.

262 - 1. This helps keep the flange from splitting open or cracking when the metal is stretched.
262 - 2. This procedure permits some of the excess metal along the tapered portion of the flange to be worked into the curve where it is needed.
262 - 3. Keep the edges of the flange as nearly perpendicular to the forming block as possible.
262 - 4. At the center, working toward the ends.
262 - 5. To allow for springback.
262 - 6. Alignment pins.
262 - 7. Stretch it.
262 - 8. Shrink it.

263 - 1. Sandbag bumping.
263 - 2. The outside dimension.
263 - 3. So that the metal can be drawn into the form block.
263 - 4. ½ to 1 inch.
263 - 5. At the edges, working toward the center.
263 - 6. The shifting of the impression in the sandbag.
263 - 7. Make a pattern to determine the amount of material needed.
263 - 8. Strike the metal with light glancing blows, about ½ to 1 inch from the edge.

264 - 1. Forming block or dies.
264 - 2. In one method, the joggle height is formed by hammering the part over a piece of metal equal to the thickness of the part over which the joggles goes. The other method, the height of the joggle is produced by another bend formed with the cornice brake.
264 - 3. Aluminum alloy.
264 - 4. The thickness of the material over which the joggle fits.
264 - 5. Use a practice piece.
264 - 6. One gage heavier than the required joggle depth.
264 - 7. The required length of the joggle minus the thickness of the joggling clip.
264 - 8. Smooth jaw vise.

265 - 1. Adjustments for thickness, width of flange (fold), sharpness (radius) of fold, and angle of fold.
265 - 2. 1 inch.
265 - 3. Pull the operating handle toward you.
265 - 4. Unlimited.
265 - 5. 3°.
265 - 6. Thickness of the metal to be bent.
265 - 7. The edge of the leaf should be $\frac{1}{64}$ inch below the bed edge at the ends and $\frac{1}{32}$ inch below the bed edge at the center.
265 - 8. Use a straightedge.
265 - 9. The clamping leaf is divided into sections called fingers or shoes.
265 - 10. It permits forming of all four sides of a box.

266 - 1. The rear lower roller—moved upward.
266 - 2. Cylinders, cones, and arcs (curves).
266 - 3. The lower rear roller was not adjusted to produce the same radius at both ends of the cylinder.
266 - 4. Running the metal through the power-operated slip roll former in only one direction was the mistake. Each end of heavy gage material should be rolled a few inches and then the material reversed and fed into the roller.
266 - 5. The rust inhibitor should be removed from the rollers, with steel wool if necessary, and the rollers should be wiped with an oiled rag.

267 - 1. Flange height, bend radius, metal thickness, and degree of bend.
267 - 2. The holddown tool presses down on the metal, holding it firmly against the anvil. Then, the brakehead tool swivels up and forms a small portion of the flange. As the brakehead begins to return to its original position, the holddown tool rises and allows the operator to slide the metal a little.
267 - 3. Four.
267 - 4. The thickness of the metal being formed.
267 - 5. After the flange has reached approximately 60°.

268 - 1. The flange is shrunk.
268 - 2. Down and outward.
268 - 3. Equally placing strokes on the flange being formed.
268 - 4. Enter the workpiece to about the centerline of the jaws and feed the work through the machine in equal distances for each stroke of the jaws.
268 - 5. Periodically remove the jaws, disassemble them, and clean them of grease and metal deposits.

269 - 1. To form flanges around holes, as well as to press into place bushings and other objects requiring a tight fit.
269 - 2. By pressing a lever which transfers pressure through a rack and pinion gear arrangement.
269 - 3. To avoid cracks or failures, when pressure is applied.

270 - 1. Wherever two bends intersect.
270 - 2. At the intersection of the inside bend tangent lines.
270 - 3. The thickness of the metal being bent.
270 - 4. To reduce unnecessary weight.
270 - 5. To strengthen the area from which the material was removed.

271 - 1. Scroll shear.
271 - 2. Whether the cut is to start at the outside or inside of the piece of metal.
271 - 3. Because the frame of the shear never obstructs the cutting operation.
271 - 4. Cutting angles of specific degrees.
271 - 5. Cutting duplicate pieces of metal to desired size and shape without repeated layout work.

272 - 1. Diameter of the cut.
272 - 2. The cutter should be separated slightly, but this open should be limited to a maximum of 10 percent of the metal thickness.
272 - 3. For light gage metal, the cutter should just touch and operate freely.
272 - 4. One-half the diameter of the circle to be cut.

273 - 1. When the metal isn't cutting square.
273 - 2. For cutting a number of pieces to a specific size.
273 - 3. You do this by inserting the metal between the blades and cutting off approximately one-quarter of an inch of metal. Square the remaining edges by holding the trimmed edge against the side gage and by making cuts one edge at a time.
273 - 4. The holddown is automatically lowered on the power-operated squaring shear when the cut is made.
273 - 5. Check the data plate to see if the metal being cut is within the capacity of the machine, and check to see if the machine is clear of material and personnel.

274 - 1. Portable unishear.
274 - 2. When they are installed.
274 - 3. Because they are throatless.
274 - 4. Upper cutting blade.
274 - 5. Too little cutting pressure.

275 - 1. Ketts circle saw.
275 - 2. Hole saw.
275 - 3. Reciprocating saw.
275 - 4. Thickness of the material being cut.
275 - 5. Too much force applied to the metal during the cutting operation.

276 - 1. Width of the saw blade.
276 - 2. Check for dullness, insufficient set, broken teeth, and faulty welds.
276 - 3. At least 2 teeth must be on the cutting surface at all times.
276 - 4. Width of the saw blade.
276 - 5. Movable jaw.
276 - 6. At a location which removes the old welded area.
276 - 7. A taut tension is preferred because it prevents the blade from twisting or wavering in the kerf.
276 - 8. When the saw blade runs in the guides with its back edge touching the rollers.
276 - 9. The thickness of the material being cut, plus one eighth of an inch.
276 - 10. Goggles or face shield.

277 - 1. Silicon carbide.
277 - 2. Rubber-bonded wheels.
277 - 3. You should dress the grinding wheel.
277 - 4. One eighth of an inch (maximum).
277 - 5. Cracked wheels should be discarded.
277 - 6. Goggles.

278 - 1. To aid in locating the center point on the cutting die.
278 - 2. By punching through several thickness of stiff paper and checking the cutout area for cutout clearance between the dies.
278 - 3. Make sure they match.
278 - 4. Because the holes will most likely be center punched.
278 - 5. Punch die is too small.

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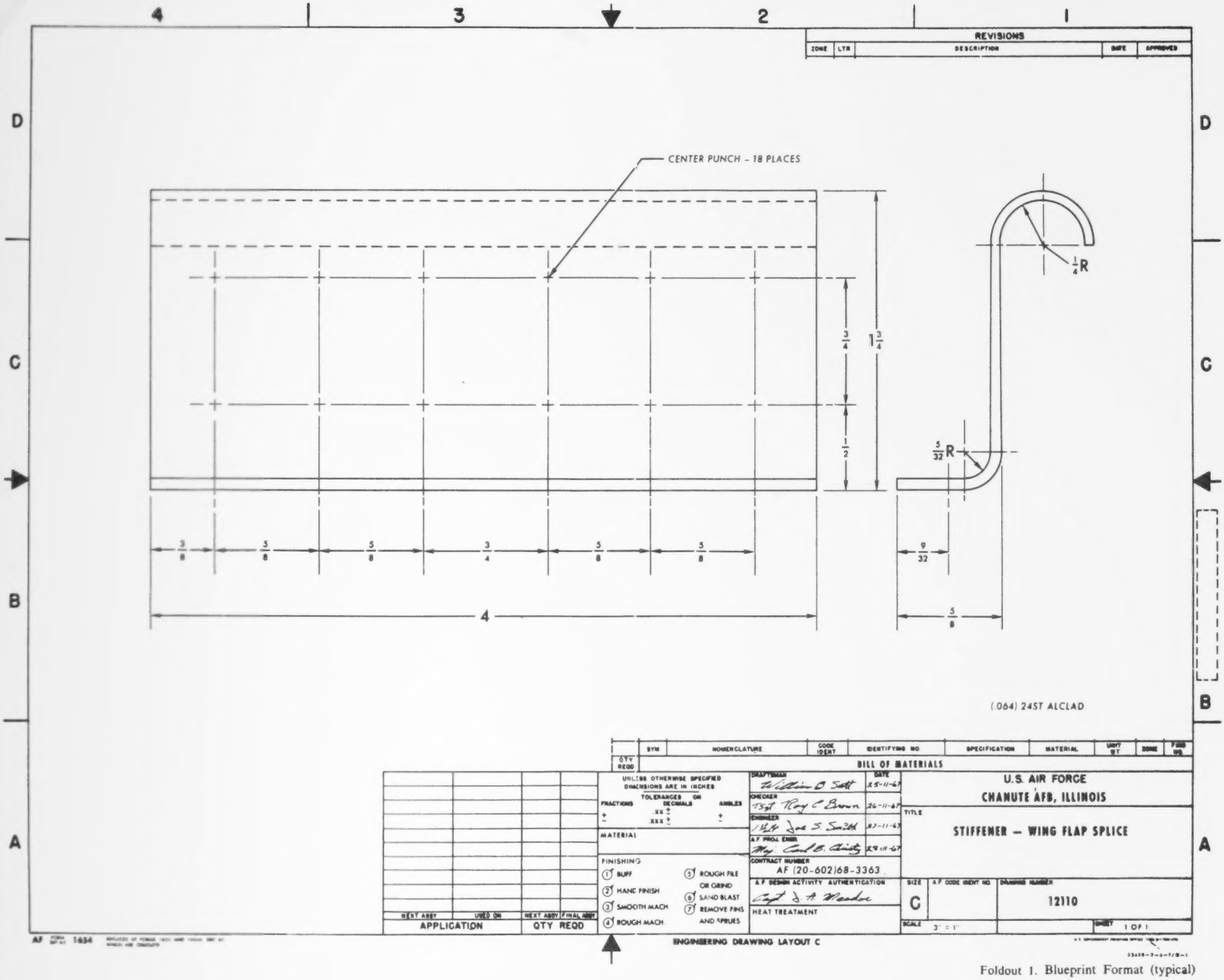

Foldout 1. Blueprint Format (typical)

STOP-

1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.

2. USE NUMBER 2 PENCIL ONLY.

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EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
FUNDAMENTALS OF METALWORKING

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if a all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DON'TS:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed.* Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

Multiple Choice

1. (200) When an aircraft is landing, the aerodynamic forces of

   a. drag and lift are increased.
   b. thrust and lift are decreased.
   c. drag and thrust are increased.
   d. gravity and lift are decreased.

2. (200) A rough surface produces turbulence which

   a. reduces lift and increases drag.
   b. increases lift and reduces drag.
   c. increases gravity and drag.
   d. reduces thrust and lift.

3. (201) Why is a true monocoque type of fuselage construction seldom used in modern aircraft?

   a. Lack of cross-section shape members.
   b. Lack of a stress carrying member.
   c. High cost of construction.
   d. Strength-to-weight problem.

4. (201) Which one of the following fuselage structural damages would be considered the most serious?

   a. Stringer.
   b. Longeron.
   c. Former.
   d. Skin.

5. (202) The principal structural members of the wing are the

   a. stiffeners.
   b. stringers.
   c. spars.
   d. ribs.

6. (203) Which one of the following control surfaces is found on the empennage section of an aircraft?

   a. Slats.
   b. Elevator.
   c. Flaps.
   d. Aileron.

7. (204) The primary control surface which furnishes control about the longitudinal axis of an aircraft is located on the

   a. vertical stabilizer.
   b. horizontal stabilizer.
   c. outboard section of the wing.
   d. inboard section of the wing.

8. (205) The property of metal which permits the bending of tubing without breaking is

   a. ductility.
   b. malleability.
   c. elasticity.
   d. toughness.

9. (206) The basis for comparing the desirability of the various material used in airframe construction is the

   a. corrosive properties.
   b. workability.
   c. strength-to-weight ratio.
   d. ease of attachment.

10. (207) Which one of the following type stresses in an aircraft is a combination stress?

a. Tension.
b. Shear.
c. Bending.
d. Compression.

11. (207) In bending a piece of metal in a cornice brake, what stresses are encountered in the metal?

a. Compression and shear.
b. Shear and tension.
c. Torsion and tension.
d. Tension and compression.

12. (208) Besides a high strength-to-weight ratio, which one of the following factors is the most important reason for using aluminum in the construction of aircraft?

a. Corrosion resistance.
b. Appearance.
c. Ease of attachment.
d. Ease of fabrication.

13. (209) When identifying aluminum alloys in the 1xxx group of the four-digit index system, what is the maximum amount of alloying elements found in this group?

a. 1 percent.
b. 10 percent.
c. 30 percent.
d. 70 percent.

14. (209) In the chemical testing of aluminum alloys, heat-treatable or non-heat-treatable alloys are based on the chemical's reaction to the

a. alclad coating on the surface.
b. oxygen content of the metal sample.
c. alloy element in the base metal.
d. pure aluminum in the base metal.

15. (210) If you had to select an aluminum alloy high in strength without a substantial loss in workability, which one of the following alloys would you select?

a. 1,000.
b. 1,100.
c. 3,003.
d. 5,052.

16. (211) Compared to aluminum, titanium alloys, which are 60 percent heavier than aluminum, are much stronger and show

a. a higher fatigue resistance than aluminum.
b. a lower rate of corrosion at elevated temperatures than aluminum.
c. excellent cold-working properties similar to stain-hardened aluminum alloys.
d. an increase in hardness as density increases.

17. (211) In the A-B-C classification of titanium the "C" identifies crystals of

a. commercially pure titanium.
b. corrosion-resistant titanium.
c. heat-treatable alpha materials.
d. moderate contamination resistance.

18. (212) If the -3 technical order specified TI-6Al-4V as the repair material, the metal would be

a. commercially pure titanium.
b. titanium alloyed with 6 parts aluminum and 4 parts vanadium.
c. titanium alloyed with 6 percent aluminum and 4 percent vanadium.
d. titanium alloyed with 6 tenths of 1 percent aluminum and 4 tenths of 1 percent vanadium.

19. (213) The lightest structural metal in use today is

a. aluminum.
b. magnesium.
c. titanium.
d. stainless steel.

20. (213) What is the critical temperature range of magnesium alloys compared to the coefficient of thermal expansion?

a. 30° to 100° F.
b. 50° to 150° F.
c. 70° to 212° F.
d. 150° to 300° F.

21. (214) The ASTM nomenclature system is used exclusively in designating magnesium and magnesium alloys. The principal alloy elements are indicated by the

a. numbers.
b. first two letters.
c. hyphenated suffix.
d. the numbers proceeding the letter X.

22. (214) What test can best be used to identify aluminum from magnesium when the identification markings have been obliterated?

a. Magnetic.
b. Weight.
c. Spark.
d. Spot.

23. (215) The classification of metals as ferrous or nonferrous is based on the

a. amount of alloying elements.
b. percentage of iron used as an alloying element.
c. percentage of carbon used as an alloying element.
d. number of heat-treatments processes that can be performed on the metal.

24. (216) What is the best method to employ when identifying steels using the spark test method?

a. Set the grinding wheel speed at 3,500 feet per minute.
b. Observe the spark stream against a dark background.
c. Compare known sparks streams with spark stream of sample piece.
d. Grind the metal on the side of grinding wheel to obtain a large volume of sparks.

25. (217) If a repair figure specified a material of SAE 1030 steel, what would be the primary alloying element and what percentage of that element would the steel contain?

a. Nickel, 0.30 percent.
b. Carbon, 0.30 percent.
c. Chrome, 0.30 percent.
d. Carbon, 3 percent.

26. (217) Which one of the following nickel-alloyed steels would you select for use in areas of application where corrosion resistance at elevated temperatures is required?

a. Inconel.
b. K-monel.
c. Hastelloy alloys.
d. Cobalt base alloys.

27. (218) The purpose for aging an aluminum alloy at a specified temperature during heat-treatment is to prevent the dissolved constituents from

a. age hardening.
b. corroding.
c. going into solid solution.
d. precipitating out of solution.

28. (219) The number of times alclad aluminum can be reheat-treated is based on the

a. material composition of the metal.
b. thickness of the metal.
c. amount of forming accomplished.
d. size of the part.

29. (220) To prevent cracks in titanium repair parts, after fabrication, the cracks should be

a. stress relieved.
b. solution treated.
c. annealed.
d. aged.

30. (220) The higher the solution temperature for titanium, the lower the final

a. hardness.
b. ductility.
c. strength.
d. corrosion resistance.

31. (221) When nickel base alloys containing elements such as copper, aluminum or titanium are age hardened, there is an increase in

a. strength and hardness.
b. heat resistance and hardness.
c. strength and corrosion resistance.
d. corrosion resistance and hardness.

32. (222) When shearing the hardened aluminum alloy 7075-T6, what is the limitation on thickness for the sheet being sheared?

a. 0.400-inch thickness.
b. 0.300-inch thickness.
c. 0.200-inch thickness.
d. 0.100-inch thickness.

33. (222) While reaming holes in aluminum, what is the most probable cause if the reamer starts to scrape and swedge the material rather than to cut?

a. Holes were drilled oversize.
b. Holes were drilled undersize.
c. Spirals on the reamer are opposite to the rotation of the reamer.
d. Spirals on the reamer are pointed in the same rotation of the reamer.

34. (223) What type of grit abrasive sheet should be used for the final sanding of titanium parts?

a. Number 120.
b. Number 150.
c. Number 180.
d. Number 240.

35. (223) Lack of constant pressure when drilling titanium results in

a. undersize holes.
b. hardening of metal.
c. annealing of metal.
d. contamination of metal.

36. (224) When cold bending a radius in magnesium alloy of the annealed condition, the radius should be at least equal to how many thicknesses of the material of the metal being bent?

a. 3.
b. 5.
c. 7.
d. 9.

37. (224) Since wrought magnesium alloys tend to crack after they are cold-worked, the best results are obtained if the metal is

a. stress relieved after forming.
b. heated to 450° F. prior to forming.
c. heated to 450° F., then stress relieved.
d. annealed prior to forming and annealed again after the forming operation.

38. (225) When you find it necessary to saw thin, light corrosion-resistant steel with a hand hacksaw, the number of teeth per inch on the blade should be

a. 14.
b. 18.
c. 24.
d. 32.

39. (226) Of the four conditions for corrosion, which one can best be controlled by you?

a. Metal anode.
b. Cathode.
c. Conductor.
d. Electrolyte.

40. (226) The initial rate of corrosion is usually much greater than the rate after a short time because

a. there is a reduction in the electrolyte.
b. the oxide film formed will protect the metal underneath.
c. an increase in temperature will result.
d. the flow of electrons is reversed when corrosion starts.

41. (227) The rusting of iron, tarnishing of silver, the fogging of nickel, and the high temperature oxidation of iron or stainless steels are typical versions of

a. uniform etch corrosion.
b. galvanic corrosion.
c. exfoliation corrosion.
d. stress corrosion.

42. (227) Intergranular corrosion usually results from the effect of

a. section size.
b. material selection.
c. environment.
d. heat-treatment.

43. (229) Which one of the following working practices does <u>not</u> apply toward preventing marks or scratches on the surface of titanium?

a. Protect the metal surface by employing vise jaw protection when filing.
b. Separate sheets in the storage rack by a 15-pound basic weight paper.
c. Use a soft leaded pencil to mark layout lines.
d. Use a scriber only for cut lines.

44. (230) When substituting a thinner metal which is stronger than the original metal, you

a. decrease torsional strength.
b. increase torsional strength.
c. increase buckling strength.
d. decrease shear strength.

45. (231) If the following pliers are available to use for crimping a thin piece of sheet metal, which should you select?

a. Half roundnose.
b. Roundnose.
c. Flatnose.
d. Dikes.

46. (231) Round stock is best held with

a. combination pliers.
b. roundnose pliers.
c. half-roundnose pliers.
d. clamp pliers.

47. (232) Practically all box-end wrenches are made with 12 points so that

a. odd size nut and bolts can be removed.
b. twelve different type nuts can be removed.
c. a 15° pull can be accomplished in close quarters.
d. a full swing can be accomplished in close quarters.

48. (232) Thw wrench used to loosen or tighten setscrews or capscrews with recessed heads is the

a. Allen wrench.
b. socket wrench.
c. torque wrench.
d. crescent wrench.

49. (233) If you had to remove screws in close quarters, you would select a

a. ratchet-type screwdriver.
b. an extension-type screwdriver.
c. small handled common screwdriver.
d. a screwdriver with tips set at right angles to each other.

50. (233) When grinding the tips of screwdrivers, the end of the tip should be

a. parallel to tip faces.
b. slightly convex.
c. at a right angle to the face.
d. slightly concave.

51. (234) If you are assigned the task of tucking the edges of a sheet metal stock, which one of the following hammers would you select for the job?

a. Setting hammer.
b. Stretching hammer.
c. Planishing hammer.
d. Shrinking hammer.

52. (234) When replacing a hammer handle, you can eliminate any slight tendendy of the head to slip in either direction by

a. driving the handle a little farther into the hammer head.
b. driving the steel wedge a little farther into the handle.
c. using a larger than required steel wedge.
d. taping the portion of handle inserted in the hammer head.

53. (235) Which of the following punches could be used in place of a prick punch to establish location points on sheet stock?

a. Pin punch.
b. Starting punch.
c. Hollow punch.
d. Transfer punch.

54. (236) The transferring of measurements from one object to another is best accomplished by using

a. a micrometer.
b. dividers.
c. a steel rule.
d. a tape measure.

55. (236) Smooth irregular curves are usually plotted and drawn with

a. a ruling pen.
b. a bow compass.
c. a French curve.
d. an erasing shield.

56. (237) If you are to insert a sleeve in the cylinder of a reciprocating engine, what type of micrometer should you use to obtain an accurate measurement of the cylinder's diameter?

a. Inside micrometer.
b. Outside micrometer.
c. Depth micrometer.
d. Clearance micrometer.

57. (237) On a micrometer, the horizontal line on the barrel reads 1/10 inch; the visible graduations on the thimble read more than 0.020 inch and less than 0.021 inch. On the vernier scale, the number 7 coincides with a line on the thimble. These factors give a total measurement of

a. 0.0127 inch.
b. 0.1270 inch.
c. 0.1207 inch.
d. 1.0270 inches.

58. (238) You would most likely use a thickness gage to

a. determine clearance between parts.
b. check thickness of a piece of metal.
c. indicate the height of rivet shop heads.
d. locate the center of tapered skin panels.

59. (239) Which one of the following snips is best suited for enlarging small holes in sheet metal?

a. Straight.
b. Aviation.
c. Tinner.
d. Offset.

60. (240) If you sharpen the blades on a pair of straight snips, you should use a

a. flat file.
b. square file.
c. mill file.
d. beveled file.

61. (241) A properly sharpened chisel would have a cutting angle of between

a. 75° to 85°.
b. 60° to 70°.
c. 35° to 45°.
d. 15° to 30°.

62. (242) A hacksaw blade having 24 teeth per inch should be used to saw

a. thick wall tubing.
b. the wall tubing.
c. solid stock aluminum.
d. cast iron.

63. (243) What is the results when the fraction 1/8 is subtracted from the sum of the fractions 3/4 and 5/32?

a. 29/64.
b. 25/32.
c. 11/16.
d. 1 1/16.

64. (243) When the common fraction 3/4 is multiplied by the common fraction 8/9, the result is

a. 9/16.
b. 27/32.
c. 3/8.
d. 2/3.

65. (244) Which one of the following sets of decimals produce the product 261.44744?

a. 43.286 and 6.04.
b. 17.314 and 151.0.
c. 71.601 and 36.51.
d. 105.585 and 24.7.

66. (244) When the decimal 0.78 is divided by 0.964, the result is

a. .403.
b. .672.
c. .779.
d. .809.

67. (245) What measurement system is legally recognized by the United States?

a. English system.
b. Metric system.
c. Kilogram system.
d. Liter system.

68. (245) The kilogram used in the metric system when compared to the English system pound is

a. 1.500 pounds lighter.
b. 2.046 pounds heavier.
c. .240 pounds lighter.
d. 2.204 pounds heavier.

69. (246) Which of the following expressions is used to measure volume in the metric system?

a. Metric ton.
b. Kilogram.
c. Centimeter.
d. Milliliter.

70. (246) The key to understanding the metric system lies in the

a. categories of measurement divisions.
b. comparison of the metric and English systems.
c. prefixes that describe the basic root words.
d. basic root of meter, gram, and liter.

71. (247) What descriptive drawing term is used to describe the greatest dimension lying in the same plane of the object?

a. Width.
b. Length.
c. Height.
d. Thickness.

72. (248) A thin line consisting of alternating and evenly spaced long and short dashes is called a

a. centerline.
b. border line.
c. dimension line.
d. hidden line.

73. (248) Drawing lines which have arrowheads on each end of the line are known as

a. cutting plane lines.
b. sectioning lines.
c. dimension lines.
d. extension lines.

74. (249) When dimensioning holes, dimensions are usually given

a. in notes to one side of the holes.
b. from the center to center of each hole.
c. from the outside to the outside of each hole.
d. in the form of symbols representing abbreviated measurements.

75. (250) If you were to use a drawing that showed the final positioning and attachment of parts in an aircraft, what type of drawing would you be using?

a. Installation drawing.
b. Assembly drawing.
c. Detail drawing.
d. Production drawing.

76. (250) When it is necessary to show internal parts of an object, you should use

a. a design drawing.
b. a subassembly drawing.
c. a sectional drawing.
d. an assembly drawing.

77. (251) To locate a specific point on a drawing, you should use the

a. station numbers.
b. zone numbers.
c. drawing numbers.
d. usage block numbers.

78. (251) If the tolerance on a blueprint is an allowable tolerance of 1.374 + .0035 - .0010, the acceptable tolerance is

a. .0010.
b. .0025.
c. .0035.
d. .0045.

79. (252) What advantage is there in placing drawings and blueprints on microfilm?

a. Large amounts of information can be stored for quick reference.
b. Original drawings can be kept for a longer period of time before being modified.
c. Dimensions can be measured easier.
d. Additional repair procedures can be inserted whenever required.

80. (253) It is permissible to make a single-view drawing of an object when

a. the object is perfectly flat.
b. the object is bent or curved.
c. one side of the object is inclined.
d. the length and width of the object are the same.

81. (253) When considering surface drawings, an auxiliary view is used to show

a. an additional view of the side.
b. a surface appearance viewed at a 45° angle.
c. a surface appearance viewed at a 90° angle.
d. a common view of an orthographic projection.

82. (254) A surface drawing of a box with square corners is an example of

a. an orthographic drawing.
b. an isometric drawing.
c. an oblique drawing.
d. a perspective drawing.

83. (254) In an oblique drawing, the object is placed

a. parallel to the plane of projection.
b. at right angles to the projection.
c. conveniently for the illustrator.
d. on the same plane as the projection.

84. (255) Which one of the following layout tools provides the most accurate measurements when you use geometric construction to lay out an object?

a. Steel rule.
b. Tape measure.
c. Dividers.
d. Pencil compass.

85. (256) The amount of metal needed to form a bend in a piece of metal is called

a. radius of bend.
b. set back allowance.
c. degree of bend.
d. bend allowance.

86. (256) A bend in sheet metal begins at the

a. sight line.
b. mold point.
c. neutral point.
d. bend tangent line.

87. (257) What is the required amount of set back needed when the bend radius is 1/4 of an inch and the metal thickness is .063?

a. .187.
b. .313.
c. 5/16".
d. 3/8".

88. (257) The number of calculations required is setback and bend allowance is determined by the

a. thickness.
b. radius of bend.
c. degree of bend.
d. type of material.

89. (258) The forming process that involves the use of a smooth face forming dolly is called

a. crimping.
b. pleating.
c. bumping.
d. seaming.

90. (258) On ordinary pieces of flat metal, the most common method of stretching is accomplished by

a. using hardwood forming blocks.
b. hammering on areas supported by an anvil or similar base support.
c. using V-blocks to force the metal outward toward the edges.
d. compressing or forcing material into a smaller area.

91. (259) If you had to form concave and convex curves on extruded angles, which one of the following form blocks would you use?

a. Stretching blocks.
b. Shrinking blocks.
c. V-blocks.
d. Dolly blocks.

92. (259) To rivet, form, and seam square or rectangular shaped materials, you would select a

a. solid mandrel stake.
b. blow horn stake.
c. creasing stake.
d. conductor stake.

93. (260) To curve a formed angle which has wide flanges use

a. V-blocks.
b. joggle blocks.
c. forming blocks.
d. shrinking blocks.

94. (260) If it is necessary to add additional crimps to shrink a formed angle, you should place them

a. in the location of the original crimps because of the thicker metal.
b. on the ends of the formed angle to increase the curvature.
c. between the original crimps to decrease the work needed to harden any one point.
d. only in the middle of the formed angles because shrinking has compressed more metal into the center area.

95. (261) When forming a flanged angle using shrinking or stretching procedures involving the use of wooden form blocks, the flange is planished by using a

a. metal shrinking hammer.
b. soft-faced mallet.
c. small hardwood wedge block.
d. lightweight setting mallet.

96. (261) When a convex flanged angle is formed using wooden form blocks, the metal must be

a. bumped.
b. crimped.
c. shrunk.
d. stretched.

97. (262) To prevent the splitting or cracking of the metal when forming concave and convex flanges, you should

a. form the convex flange first.
b. form the concave flange first.
c. use the same hammering directions for both flanges.
d. strike the metal with glancing blows, at an angle of approximately 30° off perpendicular.

98. (262) To correctly form an inside flange on a curved part, you start hammering at the

a. center until the flange is approximately bent to a 45° then work the ends toward the center.
b. endings, working toward the center only if the flange is less than 1 inch in width.
c. beginning of the bend and continue toward the center.
d. center working toward each end.

99. (263) Which type of bumping process involves making a paper pattern of the part to be formed?

a. die bumping.
b. sandbag bumping.
c. form block bumping.
d. V-block bumping.

100. (264) The distance between the bends of a joggle formed on a cornice brake is equal to the

a. metal thickness of the part over which the joggle is being placed.
b. length of the flange over which the joggle is being placed.
c. metal thickness of the part over which the joggle is being placed plus the thickness of the joggle material.
d. metal thickness of the part over which the joggle is being placed plus 1/16 inch for each bend radius.

101. (264) It is necessary to use forming dies to make a joggle in metal parts when the joggle is to be made on a

a. wedge block.
b. straight flange.
c. flat piece of metal.
d. curved flange.

102. (265) If the stock material is within the capacity of the machine, what is out of adjustment if a bar folder is hard to operate when bending sheet stock?

a. Thickness adjustment.
b. Width adjustment.
c. Radius adjustment.
d. Angle adjustment.

103. (265) The process of duplicating angles on a cornice brake may be speeded up by

a. adjusting the depth of the back gage.
b. setting the stop gage to the desired angle.
c. overlapping the parts to be formed.
d. adjusting the clamping bar and increasing the bend radius.

104. (266) A conical shape can be formed with the slip roll formed by

a. setting the back roller at an angle.
b. using the grooved portion of the rolls.
c. feeding the metal through the roller on a diagonal.
d. reversing the metal after each pass through the rollers.

105. (267) Which part of the power flanging machine actually bends the flange during the flanging operation?

a. Brakehead tool.
b. Pull down tool.
c. Hold down tool.
d. Setting head tool.

106. (267) When using the power flanging machine, which die selection factor directly affects the required adjustments?

a. Bend radius.
b. Height of flange.
c. Degree of bend.
d. Material thickness.

107. (267) Since it normally takes four passes to complete a flange on the power flanging machine, on which pass would you shift the machine to high speed?

a. First.
b. Second.
c. Third.
d. Fourth.

108. (268) What position should the foot lever of the stretching and shrinking machine be in while adjusting the dies for material thickness?

a. Back position.
b. Neutral position.
c. Positive position.
d. Negative stroke.

109. (268) If the forming dies on the shrinking and stretching machine fails to grip the metal during the forming operation, what action should you take to

a. readjust the clearance setting larger.
b. shorten the foot lever stroke.
c. remove the dies and clean with light oil.
d. insert shims under both dies.

110. (268) When stretching a flange on the stretching and shrinking machine, the edges of the flange will be cracked or split the most quickly by

a. stretching the flange too quickly.
b. under-adjusting the length of foot stroke.
c. repeating the strokes too long at one spot.
d. using the wrong set of jaws in the machine.

111. (269) The leverage applied to the handle of the hand-operated arbor press is transmitted to the work piece through the

a. ram, to the rack, and to the pinion gear.
b. make die, to the ram, and to the pinion gear.
c. rack, to the chain assembly, and to the ram.
d. pinion gear, to the rack, and to the ram to the male die.

112. (270) Beside making room for the material contained in two intersecting flanges, another purpose for relief holes is to provide a

a. means of reducing the weight of a part.
b. neatly trimmed corner where excess material is trimmed away.
c. way of locating the slight line for bending.
d. quick method of inspecting the internal composition of metal used.

113. (270) If you are unsure of the metal thickness being formed, how do you determine the size of a relief hole?

a. The diameter of the rivets used in the part.
b. The distance from the sight line to the inside bend tangent line.
c. The degree of bend required after forming.
d. The edge distance of the nearest rivet hole.

114. (270) The edge of a lightening hole is often stretched to

a. relieve internal strains within the part.
b. provide clearance for an extrusion.
c. form a flanged reinforcing edge.
d. reduce the weight of the part.

115. (271) The size of parts which may be cut on a scroll shear is limited by the

a. width of the cutting blades.
b. distance from the cutting blades to the yoke.
c. material composition of the material being cut.
d. amount of travel by the cutting handle.

116. (272) When setting up a hand-operated circle shear, the setscrews and locking nuts must be adjusted to

a. position the yoke arm for an increase in metal thickness.
b. align the bed of the machine to the graduated scale.
c. increase the height of the center pin on the lower disc.
d. increase or decrease clamping pressure requirements.

117. (272) How far should you place the centering pin from the cutting blades on a circle shear, if you are going to cut a 10-inch diameter circle?

a. 10 inches.
b. 5 inches.
c. 2 1/2 inches.
d. 10 times the metal thickness.

118. (273) When using a gap squaring shear, the metal is moved between the cutting blade from

a. right to left.
b. back to front.
c. left to right.
d. front to back.

119. (274) Adjustment of the cutting blades on a stationary unishear is accomplished

a. when the blades are installed.
b. when the red indicator light comes on.
c. each time a different gage material is cut.
d. each time the upper blade is raised to the upper position.

120. (275) What type of a saw should be used to remove a damaged stringer from a cutout area if a Ketts saw is not available?

a. Reciprocating saw.
b. Nibblers.
c. Fly cutter.
d. Portable unishears.

121. (275) When selecting a saw blade to use in a reciprocating saw, what factor must you consider to ensure proper cutting action?

a. Install the blade with the teeth facing away from you.
b. Select a blade equal to the thickness of the material being cut.
c. Select a blade to assure that five teeth cut simultaneously.
d. Select a blade pitch that will have two teeth cutting at all times.

122. (276) In order to use the job selector dial on a contour metal cutting saw, what information must you know?

a. The pitch of the material based on thickness.
b. The type of blade already installed in the machine.
c. Material composition and thickness of the material being cut.
d. The radius of the material being cut.

123. (277) When grinding 3/8-inch thick material on a grinding machine, what is the maximum distance separating the tool rest from the grinding wheel?

a. 1/16 inch.
b. 1/8 inch.
c. 1/4 inch.
d. 3/8 inch.

124. (277) If the piece of metal being punched by a Whitney punch has several holes misaligned, which operation was probably overlooked?

a. The intended holes were not centered punched.
b. The center lines for the holes are too close to the edge of the sheet.
c. The wrong size punch was installed.
d. The punch and die are out of alignment.

STUDENT REQUEST FOR ASSISTANCE

PRIVACY ACT STATEMENT

AUTHORITY: 44 USC 3101. PRINCIPAL PURPOSE(S): To provide student assistance as requested by individual students. ROUTINE USES: This form is shipped with every ECI course package. It is utilized by the student, as needed, to place an inquiry with ECI. DISCLOSURE: Voluntary. The information requested on this form is needed for expeditious handling of the student's need. Failure to provide all information would result in slower action or inability to provide assistance.

SECTION I: CORRECTED OR LATEST ENROLLMENT DATA: MAIL TO: ECI, GUNTER AFB, ALA 36118

1. THIS REQUEST CONCERNS COURSE
2. TODAY'S DATE
3. ENROLLMENT DATE
4. PREVIOUS SERIAL NUMBER
5. SOCIAL SECURITY NUMBER
6. GRADE/RANK
7. INITIALS
LAST NAME
8. OTHER ECI COURSES NOW ENROLLED IN
9. ADDRESS: (OJT ENROLLEES - ADDRESS OF UNIT TRAINING OFFICE/ALL OTHERS - CURRENT MAILING ADDRESS)
ZIP CODE
10. NAME OF BASE OR INSTALLATION IF NOT SHOWN ABOVE:
11. AUTOVON NUMBER
12. TEST CONTROL OFFICE ZIP CODE/SHRED

SECTION II: Old or INCORRECT ENROLLMENT DATA

1. NAME:
2. GRADE/RANK:
3. SSAN:
4. ADDRESS:
5. TEST OFFICE ZIP/SHRED:

SECTION III: REQUEST FOR MATERIALS, RECORDS, OR SERVICE

(Place an "X" through number in box to left of service requested)

ADDITIONAL FORMS 17 available from trainers, OJT and Education Offices, and ECI. The latest course workbooks have a Form 17 printed on the last page.

1	EXTEND COURSE COMPLETION DATE. (Justify in Remarks)
2	SEND VRE ANSWER SHEETS FOR VOL(s): 1 2 3 4 5 6 7 8 9 - ORIGINALS WERE: NOT RECEIVED, LOST, MISUSED
3	SEND COURSE MATERIALS (Specify in remarks) - ORIGINALS WERE: NOT RECEIVED, LOST, DAMAGED.
4	COURSE EXAM NOT YET RECEIVED. FINAL VRE SUBMITTED FOR GRADING ON (Date):
5	RESULTS FOR VRE VOL(s): 1 2 3 4 5 6 7 8 9 NOT YET RECEIVED. ANSWER SHEET(s) SUBMITTED ON (Date):
6	RESULTS FOR CE NOT YET RECEIVED. ANSWER SHEET SUBMITTED TO ECI ON (Date):
7	PREVIOUS INQUIRY (ECI FORM 17, LTR, MSG) SENT TO ECI ON:
8	GIVE INSTRUCTIONAL ASSISTANCE AS REQUESTED ON REVERSE:
9	OTHER (Explain fully in remarks)

REMARKS: (Continue on Reverse)

OJT STUDENTS must have their OJT Administrator certify this request.	I certify that the information on this form is accurate and that this request cannot be answered at this station. (Signature)
ALL OTHER STUDENTS may certify their own requests.	

ECI FORM 17 JUN 77 PREVIOUS EDITIONS MAY BE USED

SECTION IV: REQUEST FOR INSTRUCTOR ASSISTANCE

NOTE: Questions or comments relating to the accuracy or currency of textual material should be forwarded directly to preparing agency. Name of agency can be found at the bottom of the inside cover of each text. All other inquiries concerning the course should be forwarded to ECI.

VRE ITEM QUESTIONED:

Course No. _____

Volume No. _____

VRE Form No. _____

VRE Item No. _____

Answer You Chose (Letter) _____

Has VRE Answer Sheet been submitted for grading?

☐ YES ☐ NO

MY QUESTION IS:

REFERENCE
(Textual support for the answer I chose can be found as shown below)

In Volume No: _____

On Page No: _____

In_____ (Left)_____(Right) Column

Lines_____Through_____

Remarks:

53153 00 S01 7904

SUPPLEMENTARY MATERIAL

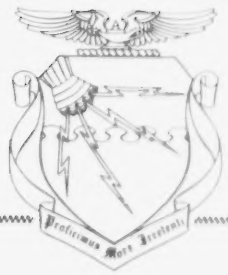
CDC 53153

AIRFRAME REPAIR SPECIALIST

(AFSC 42755)

Volumes 1 and 2

IMPORTANT: Make the corrections indicated in this supplement before beginning study of Volumes 1 and 2. This supplement contains both "pen-and-ink" changes and replacement pages. It is three-hole-punched so that you can tear out the replacement pages and insert them in your volumes.



Extension Course Institute
Air University

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CHANGES FOR THE TEXT: VOLUME 1

Pen-and-Ink Changes:

NOTE: The additional material (and figures) for this volume is valued at 3 hours (1 point).

Page-Col	*Subject*	*Line(s)*	*Correction*
Preface		12 fr bot	Change "TTOC" to "TTGOX."
14R		25 fr bot	Change "Chief of Maintenance" to "Deputy Commander for Maintenance."
14R		16 fr bot	Change "metalworking" to "fabrication."
15L		1,2	Change "Chief of Maintenance" to "Deputy Commander for Maintenance."
16R	NOTE (midpage)	3	Change "metalworking" to "fabrication."
17L		14	Change **"Principles of Operation"** to **"Principles of Organization."**
17L		27–29	Delete the sentence "According to this . . . to seven workers."
17R	022—1–4		Delete exercise 1 and renumber the remaining three as 1, 2, and 3 respectively.
19L		4,5 fr bot	Delete "Performance below this range of performance that is considered acceptable."
20R		11	Delete the word "three."
22L		16–23	Delete entire paragraph entitled **"Complaint Program."**
22L	027-2		Change "three" to "two."
23R		10 fr bot	Change "trainer" to "supervisor."
24L		17	Change "metals processing" to "airframe repair."
26L		11	Change "53153" to "42755."
28	Fig. 2-4	Sec 1	Change "53133" to "42735," "53153" to "42755," and "53153" to "42755."
39R	038-2	1	Change "stock" to "document."
57	Fig. 4-1		In center block and in the legend beneath the figure change "Chief of Maintenance" to "Deputy Commander for Maintenance."
57L		4	Change "Chief of Maintenance" to "Deputy Commander for Maintenance."
58R		14, 15 fr bot	Change "Chief of Maintenance" to "Deputy Commander for Maintenance."
58R		last line	Change "Chief of Maintenance" to "Deputy Commander for Maintenance."
64L		2	Change "Chief of Maintenance" to "Deputy Commander for Maintenance."
78L		10	After "individuals" insert "in your shop."
83R		8 fr bot	Change "–350" to "–35D."

Page-Col	*Subject*	*Line(s)*	*Correction*
84L		3 fr bot	Change "Chief of Maintenance" to "Deputy Commander for Maintenance."
119L		6 fr bot	Change "not" to "are."
122R		20, 21	Change "Chief of Maintenance" to "Deputy Commander for Maintenance."

Page Changes: Remove old pages and insert new pages as indicated. If the replacement pages number more than those they replace, those pages in excess of the pages being replaced will carry letter designations. For example: 20, 20a, 20b, etc.

Remove Pages	*Insert Pages*
1–8	1–8
55–56	55–56
59–62	59–62g
101–102	101–102q
105–106	105–106
127–133	127–133a

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objectives gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

The Airframe Repair Shop

WELCOME TO YOUR future and to advancement in the Fabrication Career Field. You are taking your first step toward becoming an airframe repair specialist. We will discuss two areas in this chapter: (1) career ladder progression and (2) communications security. You are required to know both of these for advancement.

1-1. Career Ladder Progression

A very important factor in your advancement is knowing where you're going. A knowledge of your own career field provides a firm foundation for you to plan your future in the Air Force. In the following objective segments we will discuss identification of the subdivisions of the Fabrication Career Field, specialty codes, skill levels, and the duties required at each skill level.

001. Identify the specialties within the Fabrication Career Field.

The Fabrication Career Field consists of specialties that in one way or another are concerned with metals. Presently six specialties make up the Fabrication Career Field: Airframe Repair, Metals Processing, Machinist, Corrosion Control, Nondestructive Inspection, and Fabrication and Parachute. Figure 1-1 illustrates an overall view of the related specialties.

Let's look at the work done by each specialty and see what type of services they can provide you as an airframe repairman.

Machinist (AFSC 427X0). The machinist manufactures and reworks machined parts. He does this through the use of various machines designed for sawing, turning, drilling, reaming, and cutting threads and gears, and he planes flat and angular surfaces. He can extract broken studs, screws, and pins.

The Metals Processing Specialist (AFSC 427X1). This man welds, forges, and solders metals in fabricating and repairing metal parts. He heat-treats steel, aluminum, magnesium, and titanium alloys.

The Corrosion Control Specialist (AFSC 427X1). This specialist uses chemical and mechanical checks and special devices to identify metals and types of corrosion. He removes corrosion and treats metals with chemicals to protect them from oxidation. He applies primers and surface coats by paint spray equipment and brushes.

Nondestructive Inspection Specialist (AFSC 427X2). This man uses various electronic devices to detect hidden defects that could cause failure of metal structures. These devices are used to find internal and external cracks, voids, hard spots, and other defects in metal structures without destroying or damaging the material.

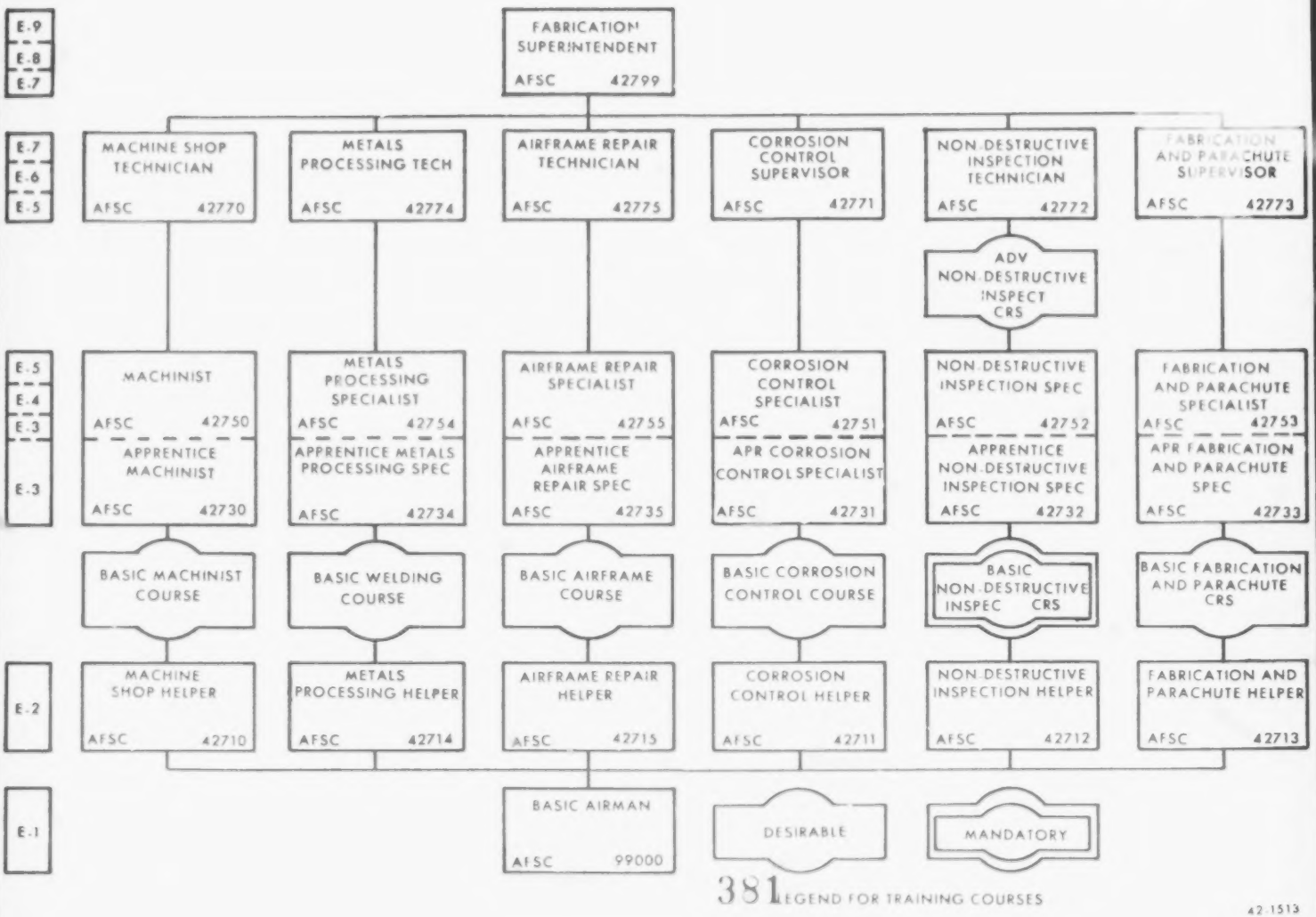
Fabrication and Parachute Specialist (AFSC 427X3). This specialist inspects, repairs, and fabricates items of fabric, and dopes aircraft control surfaces. He also performs shop repairs of rubberized items; assembles, inspects, cleans, repairs and packs deceleration, cargo, aerial delivery and flotation equipment, and personnel parachutes.

Even though all of the specialties of the Fabrication Career Field are closely related, you can see, from the brief discussion of each specialty, that a specialist in one specialty often needs help from another for special work situations.

Exercise (001):

1. In the space provided in front of each specialist title in column A place the corresponding letter in column B that identifies the specialty duty.

Column A	*Column B*
___ 1. Machinist.	a. Applies chemicals to protect metals.
___ 2. Metal processing.	b. Dopes aircraft control surfaces.
___ 3. Fabrication and parachute.	c. Locates voids and hard spots in metal.
___ 4. Corrosion control.	d. Heat-treats different types of metals.
___ 5. Nondestructive inspection.	e. Removes broken studs, screws, and pins.



1-1. Fabrication Career Field.

002. Interpret the Air Force Specialty Code (AFSC) 427X5.

Each of the specialties within the Fabrication Career Field is identified by its own AFSC. The AFSC numbering system consists of five digits. The first three digits identify the career field, the fourth digit indicates the skill level, and the fifth digit identifies the separate specialty within the career field.

Your career field is designated by the number 427 (Fabrication). Your skill level depends upon your advancement. An X placed in the fourth digit position does not indicate any particular skill level and is used only as a generality. The last digit (5) indicates the specific specialty in which you work. Yours is the airframe repair specialty. Therefore, a breakdown of your present AFSC is as follows:

427—Career Field—Fabrication.
3—Skill level—Apprentice Specialist.
5—Specialty—Airframe Repair Specialist.

Exercises (002):

1. Identify the career field indicator in AFSC 42735.

2. What is the function of the last digit in an AFSC?

3. Which digit in the AFSC changes as you advance from skill level to skill level?

003. Cite the levels of progression in the 427X5 career field.

There are three skill levels in the airframe repair specialty; the apprentice (3 level), specialist (5 level), and technicial (7 level). The apprentice skill level was awarded to you upon graduation from the basic airframe repair course. The specialist level is the level you are receiving training for now. Upon completion of all of the on-the-job training (OJT) requirements, you will be awarded the specialist level. To obtain the last level, the technician, you must be a certain rank and complete additional OJT training requirements. A complete advancement, within the airframe repair specialty, may be traced on figure 1-1.

The fabrication superintendent (9 level), which is at the top rung of the Fabrication Career Field, is not a skill level in the airframe repair specialty or in any specialty in the fabrication specialties. For you to obtain this position, you must progress through any one of the six specialties in the Fabrication Career Field and be familiar with the other five specialties. A further explanation of this level will be given in a later objective.

Exercises (003):

Refer to figure 1-1.

1. What was your AFSC when you first entered the Fabrication Career Field?

2. Give the titles and AFSCs for each step of progression from basic airman to fabrication superintendent using the airframe repair specialty ladder.

004. Cite the contents of AFR 39-1 and point out the purpose and function of an STS.

The skills and duties you must learn for advancement are not a "hit or miss" affair. To insure that you receive the right training at the right time, guidelines are used by the people directing the training. In time, you'll be called upon to conduct training, so it is important that you know how training requirements are developed.

AFR 39-1, *Airman Classification Regulation*, is the basis for all the airframe repair training you'll receive for upgrading. It describes the duties and responsibilities for all airman AFSs at the different skill levels. We'll discuss portions of this manual as we get into the different requirements for each skill level in airframe. One thing that AFR 39-1 doesn't describe is how well you should be able to perform a certain task. Some type of cutoff point must be used so that you receive the proper amount of trainng as well as the right training.

Using AFR 39-1 as the source document, a Specialty Training Standard (STS) is developed for each AFS. The STS sets the level of training you'll receive at each skill level. Your supervisor uses the STS for planning your training. As you complete each portion of the trianing, he'll indicate on the STS that you have reached the level of proficiency required. Figure 1-2 illustrates the proficiency code levels that are used on the STS.

You use this key to identify the proficiency required at each skill level, as shown in figure 1-3. Take a minute and study figure 1-3 and note how the training requirements increase as you proceed from one skill level to another.

Exercises (004):

1. What information is contained in AFR 39-1?

2. Why are STSs required?

3. How is the STS used for on-the-job training?

4. Why is a proficiency code key used with an STS?

You should be able to complete each operation satisfactorily with supervision. "With supervision" is the key phrase when discussing your duties as an apprentice. You are not expected to be highly proficient at these operations, nor to pass severe testing. But you are expected to try your best to accomplish each one satisfactorily. Also, as an apprentice, you are expected to assist a skilled specialist in the performance of his job, if help is needed. In this way you'll gain in experience and actually put to work the principles and procedures you're learning in this CDC.

005. List and characterize the duties of the apprentice airframe repair specialist.

As a apprentice specialist, you are expected to know the general principles of drilling, riveting, cutting, forming, and bonding of metal in the fabrication and repair of metal and nonmetal parts and components.

Exercises (005):

1. List the duties that an apprentice airframe repairman is expected to perform.

PROFICIENCY CODE KEY		
	SCALE VALUE	DEFINITION: The Individual
TASK PERFORMANCE LEVELS	1	Can do simple parts of the task. Needs to be told or shown how to do most of the task. (EXTREMELY LIMITED)
	2	Can do most parts of the task. Needs help only on hardest parts. May not meet local demands for speed or accuracy. (PARTIALLY PROFICIENT)
	3 *	Can do all parts of the task. Needs only a spot check of completed work. Meets minimum local demands for speed and accuracy. (COMPETENT)
	4	Can do the complete task quickly and accurately. Can tell or show others how to do the task. (HIGHLY PROFICIENT)
* TASK KNOWLEDGE LEVELS	a	Can name parts, tools, and simple facts about the task. (NOMENCLATURE)
	b	Can determine step by step procedures for doing the task. (PROCEDURES)
	c	Can explain why and when the task must be done and why each step is needed. (OPERATING PRINCIPLES)
	d	Can predict, identify, and resolve problems about the task. (COMPLETE THEORY)
** SUBJECT KNOWLEDGE LEVELS	A	Can identify basic facts and terms about the subject. (FACTS)
	B	Can explain relationship of basic facts and state general principles about the subject. (PRINCIPLES)
	C	Can analyze facts and principles and draw conclusions about the subject. (ANALYSIS)
	D	Can evaluate conditions and make proper decisions about the subject. (EVALUATION)

– EXPLANATIONS –

* A task knowledge scale value may be used alone or with a task performance scale value to define a level of knowledge for a specific task. (Examples: b and 1b)

** A subject knowledge scale value is used alone to define a level of knowledge for a subject not directly related to any specific task, or for a subject common to several tasks.

– This mark is used alone instead of a scale value to show that no proficiency training is provided in the course, or that no proficiency is required at this skill level.

X This mark is used alone in course columns to show that training is not given due to limitations in resources.

Figure 1-2. STS proficiency code key.

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1 TASKS, KNOWLEDGES AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION								
	2 3 Skill Level			3 5 Skill Level			4 7 Skill Level		
	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials
9. HANDTOOLS AND SHOP EQUIPMENT									
SR: AFR 127-101 (chap 3); TOs 32-1-101, 32-1-151, 34-1-3									
a. Select, use, and care for handtools	2b			3d			4d		
b. Select, use, and care for special tools and equipment	2b			3c			4c		

Figure 1-3. STS task progression

2. What is the main factor to consider when discussing the duties of an apprentice?

3. What is one way an apprentice gains experience?

006. List and characterize the duties of an airframe repair specialist.

We now reach the area that concerns you the most at this time — the duties of the specialist. We can discuss these duties by looking at the specialty summary for the airframe repair specialist listed in AFR 39-1.

AFR 39-1 states that, as a specialist, you should be able to "repair, modify, and fabricate aircraft metal, plastic, fiberglass, and honeycomb structural parts, components and assemblies." As you can see, the verbs are all active verbs, indicating that you perform. You should be able to complete each of these tasks with a far lesser degree of supervision than the apprentice. In fact, certain tasks that you should be able to perform, without supervision, are an indicator of your experience and training. The specialists are the people who do most of the work of the shop. Along with these duties comes your introduction to supervision. Even though most of your duties involve your doing the work, there will be times when you'll be required to supervise people. Team leader of repair crews and conducting phases of on-the-job training are two examples of situations where you'll be accountable for other people. The supervision that you perform as an airframe repair specialist will be good experience. You will need and use this experience as an airframe repair technician.

Exercises (006):

1. Where is the emphasis placed on the duties of an airframe repair specialist: knowledge, performance, or supervision?

2. List briefly the duties of an airframe repair specialist.

3. Why should you be concerned with supervision at the 5 skill level?

4. What types of supervision will you perform as an airframe repair specialist?

007. Identify technician positions and select from a list of duties those that are required of an airframe repair technician.

The specialty summary, in AFR 39-1, states that the technician "accomplishes major aircraft structural repairs; troubleshoots structural repair situations; inspects repair operations and completes repairs of metal, plastic, and bonded structural components; and supervises airframe repair activities."

As you can see, performance is still emphasized as it was for the specialist. The perfomance of the technician demands a higher degree of technical skill than that of the specialist, and a technician must also be well balanced in the knowledge and supervisory areas. The specialty summary points out that the technician supervises airframe repair activities. Because of his supervisory capability, a technician is often assigned as an airframe repair shop or shift supervisor.

Exercises (007):

1. What is the AFSC for an airframe repair technician?

2. State two positions to which a technician may be assigned.

3. In the space provided indicate whether a duty pertains to an airframe repair technician by placing the word "no or yes."

___ a. Performs welding of bonded structures.
___ b. Supervises airframe repair activities.
___ c. Assists airframe repair specialists.
___ d. Accomplishes major aircraft structural pairs.
___ e. Heat-treats metals.

008. Point out the duties of a fabrication superintendent and give his AFSC and rank required.

We now come to the top rung of your career ladder, the fabrication superintendent (42799). In a field maintenance squadron, the fabrication superintendent is usually the Fabrication Branch Chief. The shop supervisors work directly for him.

The fabrication superintendent's duties are primarily in the areas of supervision and management. The specialty summary states that he "superintends activities engaged in testing, fabricating, repairing, and machining metals and metal products; corrosion control in missile, aircraft, and support system equipment; nondestructive inspection of aerospace material parts, components and pressurized systems; the maintenance, repair, and fabrication of fabric and rubber items; and inspection, repair, and packing of parachutes and flotation equipment.

It is evident that the fabrication superintendent's duties and responsibilities are even more supervisory in nature than those of the airframe repair technician. Because of his supervisory responsibilities, a fabrication superintendent must be at least a master sergeant.

Exercises (008):

1. What is the AFSC of a fabrication superintendent?

2. What rank must a man hold before he can obtain the superintendent position?

3. Where is the emphasis placed in a fabrication superintendent's duties?

4. Circle the letters which represent the duties and responsibilities of a fabrication superintendent.

   a. Assigns specialist jobs within a shop.
   b. Directs fabrication activities.
   c. Conducts on-the-job training for apprentice specialist.
   d. Supervises shop supervisors.
   e. Performs major repairs.

1-2. Security

The degree to which you will be involved with security depends on the mission of your base, the type of equipment for which your base is responsible, and the location of the base. You may be involved with security quite often in your work, or you may seldom be involved with it. Regardless of the degree of involvement, every person in the Air Force, military and civilian, must be security-conscious. The person who works with classified information only occasionally can be a potential source of danger, simply because he is less aware of the importance of safeguarding security information.

009. Given items of information, identify each as classified, unclassified, or of possible intelligence value.

Classified information is official information, the safeguarding of which is necessary in the interest of national security. Unclassified information is information that does not require use of security safeguards, but its disclosure may be subject to control for other reasons. The target for a strategic bomber wing is classified information. The number of bombers from that wing that are on the flight line is unclassified information. However, if those bombers are being loaded with a certain type of bomb, their number becomes of possible intelligence value.

A bit of unclassified information alone may not be of any intelligence value, but when it is combined with related information, giving insight into a classified plan, each bit of information has possible intelligence value.

Keep in mind these three kinds of information: classified, unclassified, and of possible intelligence value. Always keep quiet about any job-related information, regardless of how or where you obtained it.

Exercises (009):

1. A master target plan for strategic missiles is _____ information.

2. The fact that the Air Force has sent Captain Jones to an area of undeclared war is _____ information.

3. Captain Jones is a demolition expert. Is this statement classified or unclassified?

4. Combining the information in question 2 and 3 produces information _____ .

010. Given examples of official information, give the security clearance required for each.

The basic regulation that covers security is DOD 5200.1-R, *Information Security Program Regulation.* Classified information is official information that must be safeguarded in the interest of national security. Unclassified information is official information that does not require safeguarding but may be subject to control for other reasons. Some unclassified information requires control in the public interest and is thus labeled "For Official Use Only." This means that it must be withheld from widespread distribution to the public. Examples of this type of information are notification of a shipment and personnel records. Both of these are unclassified but are For Official Use Only.

Classified Information. Security information is classified according to its importance. The highest classification is given the greatest amount of protection. The three categories of classified information in the order of their importance are as follows:

(1) Top Secret (TS).
(2) Secret (S).
(3) Confidential (C).

Quoting from DOD 5200.1-R supplemented by AFR 205-1, *Information Security Program,* Section B, Chapter 1, these categories are used as follows:

(1) Top Secret refers to that national security information or material which requires the highest degree of protection. The test for assigning Top Secret classification shall be whether its unauthorized disclosure could reasonably be expected to cause *exceptionally grave damage* to the nation security.

(2) Secret refers to that national security information or material which requires a substantial degree of protection. The test for assigning Secret classification shall be whether its unauthorized disclosure could reasonably be expected to cause *serious damage* to the national security.

(3) Confidential refers to that national security information or material which requires protection. The test for assigning Confidential classification shall be whether its unauthorized disclosure could reasonably be expected to cause *damage* to the national security.

Exercises (010):

1. Information that may lead to an armed attack against the United States or its allies is identified as _____ information.

2. Your hospital records are what type of information?

3. Information that is not in the best interests of the national security is classified as _____ information.

010a. (Objective 101 for computer answer key and feedback reference only). State the purpose of the Operations Security (OPSEC) Program and explain how you as an airframe repairman take part in this program.

From the preceding discussions of security, you know that classified information is safeguarded by physical means and by secure methods of communications. Closely related to these two safeguarding methods are the principles and procedures of Operations Security, referred to as OPSEC. In this objective segment, we'll briefly look at why OPSEC is needed and how you as an airframe repairman play an important role in the OPSEC program.

Purpose of OPSEC. OPSEC is an overall security program designed to enhance mission effectiveness. OPSEC is applicable to military activities contributing to our national security effort in peacetime as well as in wartime. It is concerned with the information and activities that are *sensitive* in the sense that they telegraph our punch to an enemy. They give him forewarning. OPSEC is intended to reduce the capability of an enemy to gather useful intelligence data about our operations and activities. Simply stated, the purpose of OPSEC is "to keep the advantage of surprise on our side." We keep the advantage on our side by protecting information and activities affecting our operations. The protection of

classified information and material is part of it. The other part is the protection of seemingly trivial or insignificant unclassified information and actions related to an operation. When these insignificant "bits and pieces" of information and actions are combined by enemy intelligence collectors, our operational effectiveness is lessened.

Your Role in OPSEC. As an airframe repairman, you have the responsibility to maintain the operational effectiveness of your squadron at the highest possible level. You do this first by quality workmanship and second by *not* becoming a security leak. How do you become a potential security leak? Very easily. The nature of your job takes you to every section of the flight line and to each maintenance shop within an organization. What you see on the flight line, such as additional aircraft, different types of aircraft, the types of weapons being loaded, are the bits and pieces of information valuable to an enemy. What you hear in the course of your conversation with other specialists is another source. The activities within your own shop can also provide the indicators the enemy needs. Minor items such as issuing weather gear (not related to your shop's location), special training, an increase of bench stock items and metal supplies, are "keys" by which the enemy can unlock our operational plans.

To avoid becoming a security leak, a good rule to follow is "Don't carry tales home from work." In other words, what goes on in the shop and flight line should be told only to those who have a *need to know*. Your neighbors, friends and family might innocently complete the "link" between you and the enemy intelligence collectors by repeating what you've told them.

Exercises (010a):

1. What is the purpose of OPSEC?

2. How can you as an airframe repairman maintain the operational effectiveness at its highest level?

3. Why are you as an airframe repairman a potential security leak?

4. What rule should you follow concerning what you see and hear in the performance of your job?

011. Indicate the physical security practices related to classified information.

Physical Security. Physical security deals with the handling and storage, transmission, and disposal of classified military information. This information may be in the form of documents, messages, or equipment. Carbon copies, rough draft, or paraphrases of original documents must also be safeguarded. The possession or use of classified material is to be limited to locations where the prescribed facilities are available for its secure storage or protection. Every person who works in a shop where there is classified material should know how to handle and store it. Classified material is handled *only* by authorized personnel who have a need for the material. It should never be discussed with unauthorized personnel. Storage requirements vary according to the security category and the type of material. At the end of normal duty hours, each safe, vault, or vault type room is inspected to insure that it is properly locked.

A safe or other safe-type container that is used for the storage of classified material should contain classified material only. Money, drugs, and other valuables should never be palced in a safe used for the storage of classified material.

Although you may never be assigned the responsibility for classified documents at any time during your military service, it is quite likely that you will find yourself in possession of classified knowledge at some time or other. This may occur through attendance at a conference, overhearing a conversation, or being exposed to classified material in the performance of your regularly assigned duties. It is for this reason that the entire matter of security as it relates to classified documents and material has been discussed. In other words, we want you to be security conscious. Then you are not likely to be guilty of even the most common security violation.

The majority of security violations are usually the result of carelessness rather than ignorance. Errors resulting in security violations can be found under any of the following basic categories: (1) unprotected papers and materials, (2) unlocked or open safes, (3) lost or misplaced documents and material, (4) failure to classify materials properly, (5) unauthorized disclosure of classified material, and (6) mailing violations. You must know where your classified material is and how it is stored.

We cannot overemphasize your obligation to safeguard military information. This is a personal responsibility that belongs to everyone whose job in any way involves the defense of the United States. You cannot exclude yourself from this responsibility regardless of what type of work you are doing in the Air Force. To use the excuse that as an airframe repair specialist you will *never* be confronted with this type of information is entirely wrong. You must remember that you are a part of the United States Air Force and that it is your responsibility to know about security.

Exercises (011):

1. Who has the right to handle classified material?

2. What factor determines where classified information can be used?

3. How could you, as an airframe repairman, be exposed to classified information?

4. What items are not stored with classified materials?

5. What factors determine the storage requirement for classified materials?

012. Distinguish between the methods of transmitting classified information in terms of types of information and advantages and disadvantages of each method.

With a knowledge of the classifications of official information, let's examine the various ways it is transmitted. For information to be useful in the conduct of official business, it must be passed from one person or place to another. Mail, telephone, radio, and messenger are modes of communication, as well as telegraph, television, and signals. We will discuss only transmission by mail, telephone, radio, and messenger. Each method has certain advantages and disadvantages.

Mail. Within our country, mail handled only by the United States Postal Service is given some protection. Registered mail, especially, requires special handling by the postal service. When the mailman brings you a registered letter, you must sign a receipt. The advantages of using mail are that the information is somewhat protected, it is inexpensive, and registered mail is documented. The disadvantages of mail service are that it is slow and mail can get into the wrong hands. Only information that is classified as Secret and below can be sent by mail.

Telephone. The telephone is a very convenient mode of communication. Two advantages of the telephone as a mode of communication are its convenience and speed. A major disadvantage of using the telephone is that conversations are easy to monitor (listen in on). The telephone must not be used for transmitting classified information or information of possible intelligence value.

Radio. In radio communication, an antenna sends radio waves through the air. If secret codes and ciphers are used to encrypt classified information, radio is a secure mode of communication. Radio, like the telephone, has the advantages of convenience and speed. Its disadvantages are that the sender has no way of knowing who is listening to his conversation, radio messages are easily monitored, and the equipment is sometimes not dependable.

Messenger. Information sent by messenger is handcarried from the sending office to the receiving office. The advantages of the messenger service are that the material is secure, receipts are required, and the material is not subject to inspection. The disadvantages of using a messenger are that the service is slow and expensive.

3. Who is responsible for the care of shop equipment?

047. Define the terms "property responsibility" and "supervisory responsibility," and cite key factors related to the Air Force collection methods when pecuniary liability is admitted.

To understand the use of the statement of charges, study the definitions of "Property Responsibility" and "Supervisory Responsibility."

Property Responsibility. The property you use in the completion of your work is your responsibility, even if its accountability lies with someone else. Each member of the Air Force is responsible for the use, care, and safeguarding of Air Force property.

Supervisory Responsibility. Supervisory responsibility applies to any person who exercises supervision over property received, in use, in transit, in storage, or undergoing modification or repair. This means that you, as a supervisor, along with the responsible person, can be held financially responsible and made to pay for property that was lost, damaged, or destroyed (pecuniary liability). If you are liable, you must pay, and the Air Force has two methods of collection: by Statement of Charges or by Cash Collection Voucher.

A Statement of Charges for Government Property Lost, Damaged, or Destroyed, DD Form 362 (fig. 3-16), is used when a person admits pecuniary liability for an item but doesn't have the cash to pay for it. The responsible individual must sign the form to authorize payroll deduction. The form is also signed by his organization commander. If the responsible individual desires to pay cash, a Cash Collection Voucher, DD Form 1131 (fig. 3-17), is used. Either form may be used if the individual admits pecuniary liability. However, if he does not admit pecuniary liability, a Report of Survey, to be discussed in our next objective, must be completed.

Exercises (047):

1. What is meant by the term property responsibility?

2. What is meant by the term supervisory responsibility?

3. When is a DD Form 362 used?

4. When is a DD Form 1131 used?

048. Identify a Report of Survey as to the form number, use, and resulting action.

A Report of Survey, DD Form 200, is illustrated in figure 3-18. A Report of Survey must be completed when pecuniary liability is not admitted. This form is an instrument for explaining and recording the circumstances surrounding the loss, damage, or destruction of Air Force property. The Report of Survey resolves questions of responsibility for the loss and fixes the pecuniary liability upon a person, persons, firm, or corporation. The DD Form 200 must be initiated immediately after it is known that loss, damage, or destruction of property has occurred and no one will admit liability. The Report of Survey must be signed by the person who had control of the property at the time of the loss, damage, or destruction. It must also be signed by the accountable officer. Upon the completion of the Report of Survey, one of two things occurs. It either supports dropping the property from the records, or it finds a person or persons liable for the loss, damage, or destruction of the property. If a person's liability is established, he must reimburse the Air Force by using a Cash Collection Voucher or a Statement of Charges, as we have already described.

Exercises (048):

1. What is the form number for a Report of Survey?

2. When is a Report of Survey initiated?

3. If a Report of Survey finds a person liable for the loss of the property, what action must be taken?

4. How can the responsible person reimburse the Air Force?

CHAPTER 4

Maintenance Management

THE AIR FORCE, like any business organization, consists of equipment, facilities, and people. The efficient use of this manpower and equipment is what maintenance management is all about. You, as an airframe repairman, are an important part of the Air Force's maintenance team, and the goals of maintenance management should be your goals.

In this chapter, we will deal primarily with how you and your shop fit into the maintenance team. First off, we'll look at two maintenance concepts in use in the Air Force today—those developed under AFM 66-1 and those developed under AFR 66-5. We'll spend most of our time looking at the organizational set-up, policies, procedures, and responsibilities associated with AFM 66-1, *Maintenance Management;* for this is the basic program upon which other maintenance concepts are developed. As for AFR 66-5, *Production Oriented Maintenance Organization,* we'll look at this program from the standpoint of how you as an airframe specialist can be assigned within this maintenance concept and what types of additional training you will receive under this maintenance concept.

The last portion of this chapter will focus on the policies and procedures by which maintenance under either AFM 66-1 or AFR 66-1 is accomplished and recorded. We'll look at the inspection system used and study the entries made on the various maintenance forms used throughout the system.

Most of the policies and procedures outlines in AFM 66-1 can be adapted to every maintenance activity. However, it must be remembered that the maintenance organization structure will vary somewhat with the size of the organization and assigned mission requirements.

4-1. Organization and Functions Related to AFM 66-1

In taking an overall look at an organization, the place to start is at the top position. It is from this position that the "pulse" of an organization originates. How good or bad an outfit performs can be directly traced to this individual. This is why the Air Force selects only the most highly qualified individual for the title of Deputy Commander for Maintenance.

049. State the qualifications and responsibilities of the Deputy Commander for Maintenance.

Deputy Commander for Maintenance. The Deputy Commander for Maintenance must be highly qualified in leadership, management, and administration, because the aircraft maintenance organization of one wing is larger and more complex than the operation of many commercial companies. The Deputy Commander for Maintenance is a position established at the highest level of operational control, and the person who occupies this position is usually the senior and is always the most qualified maintenance officer in the organization. He is the executive manager of his maintenance organization, and he exercises centralized control and direction of all functions of the activity.

Through staff agencies provided for his use as assistants: the Deputy Commander for Maintenance manages, plans, controls, executes, and produces the work needed to fulfill his functional responsibility. The staff agencies act in the name of the Deputy Commander for Maintenance on those matters for which they have been given responsibility. He and his staff must provide the direction and guidance essential for all subordinates to implement, apply, and comply with local and higher headquarters directives.

Exercises (049):

1. What are some of the qualifications for becoming a Deputy Commander for Maintenance?

2. List the functional responsibilities of the Deputy Commander for Maintenance.

3. What must the Deputy Commander for Maintenance and his staff provide for subordinates in order to have an effective maintenance team?

050. Name the sections of the Maintenance Control Branch, and identify the duties and responsibilities related to the agencies within the branch.

As previously mentioned, the Deputy Commander for Maintenance has staff agencies that work directly for him. These agencies help the Deputy Commander for Maintenance to plan, control, coordinate, and execute his responsibilities as the maintenance manager. Figure 4-1 illustrates this organizational structure. For purposes of discussion, the staff agencies are grouped into three interdependent

the problems that need improvement. Point values and objective ratings are assigned to various areas to be rated. The MSEP gives the Deputy Commander for Maintenance an excellent tool for finding weak areas in his organization and with the means to correct them. Here is an example: Personnel evaluation finds unqualified personnel assigned to perform a certain task. These persons, thus pinpointed, are singled out for further training or other corrective measures prescribed.

Weight and Balance. The aircraft quality control supervisor serves as the unit weight and balance officer. He is responsible for compliance with appropriate technical order procedures for weighing aircraft and for maintaining the required documents. Preparation, jacking, and weighing of the aircraft will be accomplished by organizational maintenance or repair and reclamation personnel under the supervision of Quality Control weight and balance personnel. Quality Control personnel will verify scale readings and perform the actual computations.

Technical Order Library. Quality Control is the responsible for maintaining an up-to-date technical order file. This includes inspection workcards, work unit code manuals, and checklists.

Modifications frequently require changes to technical orders. Each time compliance technical order (TCTO) lists the affected technical orders that must be changed as a result of the modification. Quality Control must insure that all replaced and changed pages are retained in the central file until the modification has been completley complied with by their organization.

Quality Control also inspects in-use technical orders during technical inspections to be sure that they are serviceable and up-to-date.

When revisions are necessary for any of the in-use files throughout the maintenance complex, Quality Control advises all affected activities.

When technical orders have not been published for equipment assigned to the maintenance complex, Quality Control may establish a file of commercial publications relating to this equipment as authorized in AFR 8-2, *Air Force Technical Order (TO) System*, and TO 00-5-1.

Functional Check Flight. When certain types of maintenance have been performed on aircraft, it is a technical order requirement that the aircraft be given a functional check flight. Quality Control is assigned this function. The various commanders must submit to the Functional Check Flight function of Quality Control, in writing, the crews authorized to test assigned aircraft.

The Functional Check Flight section has two important responsibilities. The first and most important is to assure that assigned aircraft are safe for flight. This is accomplished through inspection and functional testing of aircraft in flight. The second is to accurately determine and report the quality of maintenance performed by the maintenance organization.

Exercises (051):

1. What are the subdivided sections of the Quality Control Branch?

2. In the space provided in front of each of the following items, place the title of the subdivided sections in the Quality Control Branch to which the duty or responsibility belongs.

_____ a. Recommends improvement in manpower utilization.
_____ b. Performs spot checks related to quality of maintenance.
_____ c. Insures compliance with technical order procedures for aircraft returning from depot or contract overhaul.
_____ d. Excellent tool for finding weak areas.
_____ e. Develops and maintains job standards.
_____ f. Assures that assigned aircraft are safe for flight.
_____ g. Establishes a file of commercial publications.
_____ h. Responsible for compliance with technical order procedures for jacking aircraft.

052. Identify the duties and responsibilities associated with the sections that comprise the Management Support Branch.

Management Support Branch. The first two branches dealt directly with the maintenance being accomplished. The Management Support Branch deals only indirectly with the actual performance of maintenance. They handle the enormous amount of paperwork generated in the operation of a maintenance complex. This does not lessen their importance in the overall maintenance complex, as you'll see from the discussion of each of its sections.

Administration. Administration is the administrative management center of the maintenance complex and the focal point for all correspondence and reporting. Administration maintains correspondence files, prepares and submits maintenance reports, and controls maintenance administrative procedures within the maintenance complex. Classified documents and reports pertaining to equipment, such as nuclear weapons and ECM pods, are maintained and prepared by the activity to which the equipment is assigned.

The Administration activity is responsible for administrative support of the Deputy Commander for Maintenance office and the maintenance complex. Administrative duties and responsibilities are to:

a. Establish and control a reporting and administration system for all maintenance reports and correspondence.

b. Sort and group maintenance data forms before they are forwarded for keypunch.

c. In coordination with data automation, establish cutoff times for the delivery of documents or punch cards for machine processing.

d. Maintain all correspondence and report files for the Deputy Commander for Maintenance, except for the special reference files maintained by each maintenance function.

e. Insure the proper distribution of all correspondence, reports, and publications.

f. Maintain an effective correspondence and reports suspense system.

g. Insure the publication and distribution of maintenance orders, schedules, directives, procedures, reports, and summaries.

h. Accomplish the timely pickup and delivery of maintenance forms and associated reports between the maintenance activities and data automation.

Production Analysis. Production Analysis is the primary management information source for the Deputy Commander for Maintenance. It serves as a data surveillance and statistical unit. The overall objective is to provide information to be used to improve the maintenance operation. This is done through the examination of various maintenance management output products and reports and the identification of trends that are developing. This section provides guidance in the application of

production analysis techniques. It assists maintenance managers by providing guidance as to what information is available from this activity. It is not intended that all the possible variations in analysis techniques and procedures be included here. The active and questioning analyst finds sufficient guidance and suggestions which can be expanded to accommodate local conditions and requirements. All maintenance managers should become familiar with the interpretation of analysis results. Man-hour and maintenance data equipment status, and other reports received by maintenance in the form of machine listings, contain an abundance of data. As a minimum, Production Analysis duties are to:

a. Collect and maintain data pertinent to the maintenance operation, as well as to review the data for significant trends, and isolate and identify areas which need further study or investigation. When further investigation beyond the technical ability of production analysis is warranted, the problem should be referred to the appropriate staff activities or production supervisors.

b. Prepare studies, summaries, briefings, and presentations as required by the Deputy Commander for Maintenance.

c. Identify and analyze trends in equipment performance and maintenance man-hour consumption.

d. Assist maintenance staff functions by identifying and furnishing significant elements of data for use or action by these functions.

e. Assist maintenance activities in the proper application and interpretation of man-hour and maintenance data reports.

f. Coordinate with data automation on maintenance data collection input and output products to insure accuracy and timeliness.

g. Design local workcenter codes within the framework provided by AFM 300-4, *Data Elements and Codes*, ADE MA-353-XI, and TO 00-20-2. *The Maintenance Data Collection System.*

h. Provide Quality Control with necessary statistical and trend information for the Maintenance Standardization and Evaluation Program (MSEP).

Training Management. The purpose of Training Management is to insure that a continuous, well-organized training program is established and managed throughout the maintenance complex.

The maintenance training program consists of these three elements:

a. Qualification training.
b. Management training.
c. Upgrade training (UGT).

The primary role of Training Management in this program is to coordinate training requirements and schedules with the various maintenance activities. This approach permits the most effective and economical use of training resources.

Training Management provides the Deputy Commander for Maintenance and unit training supervisors with the status of training and identifies training deficiencies. In this context, training is defined as any instruction provided to increase maintenance technical qualifications and supervisory or management capability. It includes informal training conducted by supervisors and technicians from within the maintenance complex and formal training conducted by activities such as field training detachments (FTDs) and mobile training detachments (FTDs) and mobile training teams (MTTs), factory schools, and Air Training Command technical schools.

The basic responsibility for training within any organization lies directly with the squadron commander. However, the Deputy Commander for Maintenance is responsible for maintaining a balance of skills within the maintenance complex and insuring that maintenance personnel receive all necessary training. As a minimum, Training Management must:

a. Monitor the maintenance training program, as specified in AFM 66-1, *Maintenance Management*, and as further defined by the Deputy Commander for Maintenance.

b. Monitor the currency of the required proficiency evaluation, testing, qualification, and certification programs within the maintenance complex.

Programs and Mobility. Programs and Mobility provides the Deputy Commander for Maintenance with managerial support in developing and maintaining the currency of programs and plans. Also, this activity performs the function of finance, manning, and facilities management. Programs and Mobility reviews each mission

plan and assures the Deputy Commander for Maintenance that the plan is sound and all the contingencies are provided for.

An important function is the development of mobility plans for personnel and equipment. In today's Air Force, entire organizations must be in a constant state of readiness for movement. Plans and Mobility is responsible for developing internal procedures to insure that each maintenance activity is informed of mobility exercise requirements.

Exercises (052):

1. Match the letter corresponding to the section of the Management Support Branch in column B with the duties or responsibilities of that agency listed in column A.

Column A	*Column B*
_____ 1. Monitors currency of maintenance personnel certification.	a. Production Analysis.
_____ 2. Controls a reporting system for maintenance correspondence.	b. Administration.
_____ 3. Prepares studies.	c. Training Management.
_____ 4. Schedules UGT.	d. Programs and Mobility.
_____ 5. Collects and maintains maintenance data.	
_____ 6. Sorts maintenance data collection (MDC) forms.	
_____ 7. Insures publication of maintenance orders.	
_____ 8. Monitors proficiency evaluation.	
_____ 9. Statistically isolates problem areas.	
_____ 10. Picks up MDC forms from maintenance activities.	

2. In the following situation a duty or job is described. From the information given, determine the management support section that is responsible for performing each.

_____ a. This duty requires planning for fiscal control of the Deputy Commander for Maintenance budget.

_____ b. If you are going to institute a new workcenter, the responsibility for determining the code for their workcenter lies with this section.

_____ c. Handles the correspondence for the maintenance organization.

_____ d. Taking large amounts of data and analyzing and interpreting it are functions of this section.

_____ e. The keypunching activity may be located at data automation, but the sorting of cards and forms is done by this section.

053. Identify the maintenance squadrons within the maintenance complex in terms of duties, responsibilities, and structure.

The next level of maintenance we'll discuss is the units of the maintenance complex that actually perform the maintenance—the maintenance squadrons. As an airframe repairman, you'll work very closely with each of the maintenance squadrons. Therefore, a knowledge of what each maintenance squadron is responsible for will help you get an overall view of the maintenance complex and a better understanding of why things are done a certain way.

Briefly look again at figure 4-1. Take note of the bottom line. Shown are the maintenance squadrons found in a typical maintenance organizational structure. For our purposes, we'll discuss the four you will have the most contact with: the Organizational Maintenance Squadron (OMS), Avionics Maintenance Squadron (AMS), Munitions Maintenance Squadrons (MMS), and lastly, your own squadron, the Field Maintenance Squadron (FMS).

Organizational Maintenance Squadron (OMS). OMS has physical charge of all assigned aircraft. Each aircraft is, in turn, assigned to an individual usually called a crew chief. He is in charge of the aircraft, aircraft forms, as well as any maintenance personnel assigned to work on his aircraft. Actually, we could say that the whole maintenance complex is organized to support the OMS. The squadron may be divided into the following branches:

Alert Force, Base Flight and Transient, and Flight Line Inspection and Support Equipment.

Avionics Maintenance Squadron (AMS). AMS activity performs maintenance on avionics systems. Avionics systems include such equipment as radio, radar, and electronic countermeasures systems. Some of the branches within an AMS are: precision measurement equipment laboratory (PMEL), communication-navigation, and mission system. The mission system branch may consist of the following shops: bomb navigation integrated system—fire control, automatic flight control—instrument, and photographic sensors.

Munitions Maintenance Squadron (MMS). MMS provides reliable and safe munitions for both conventional and nuclear weapons. If guns are required on assigned aircraft, MMS will provide a gun service section to maintain and inspect gun system components.

The MMS may be divided into a number of branches, depending upon the size of the organization. The maximum size unit consists of: explosive ordnance disposal (EOD), equipment maintenance, nontactical instrumentation, short range attack missile (SRAM), munition services, munitions maintenance, storage, and preload.

Field Maintenance Squadron (FMS). FMS provides maintenance and specialist assistance to other maintenance squadrons. Some of the services they provide are: inspection and equipment support requirements, aircraft engine changes, corrosion control, and replacement of time change items. FMS is usually the largest squadron in the maintenance organization. It expends the most man-hours. Therefore, the way personnel and equipment are used by the FMS will greatly affect the maintenance capability. FMS consists of four branches: fabrication, propulsion, aerospace systems, and aerospace ground equipment. Figure 4-2 illustrates the organization structure for a FMS and shows the individual shops within each branch. Being an airframe repair specialist, your shop, the Structural Repair Shop, is located in the Fabrication Branch. You will work very closely with specialists within each of the branches.

Exercises (053):

1. In the space provided in front of each of the following items, place the initials of the maintenance squadron to which the item refers.

_____ a. Maintains electronic camera equipment.
_____ b. Changes aircraft engines as needed.
_____ c. Responsible for the upkeep of assigned aircraft.
_____ d. Has corrosion control capabilities.
_____ e. Maintains and inspects gun system components.
_____ f. Usually the largest maintenance squadron.
_____ g. The whole maintenance complex supports the squadron.
_____ h. Operates a PMEL section.
_____ i. Has an Alert Force Branch if required.
_____ j. Greatly affects the maintenance capability.

2. Use figure 4-2 and in the space provided in front of each of the following shops in column A, place the letter representing the branch of a FMS to which the shop belongs shown in column .

Column A	*Column B*
___ 1. Environmental.	a. Fabrication.
___ 2. Propeller.	b. Propulsion.
___ 3. Survival Equipment.	c. Aerospace systems.
___ 4. Test cell.	d. Aerospace ground equipment.
___ 5. Pneudraulics.	
___ 6. Accessory repair.	
___ 7. Powered AGE.	
___ 8. Nonpowered AGE.	
___ 9. Metals processing.	
___ 10. Electrical.	

4-1a. AFR 66-5, *Production Oriented Maintenance Organization (POMO)*

Many of the policies, procedures and functional areas of responsibility just covered for AFM 66-1 are very similar to those found in AFR 66-5. This being the case, this section will serve mainly to acquaint you with some of the major differences between AFM 66-1 and AFR 66-5 as they relate to you, the airframe repair specialist. We will first look at what POMO is and how its organizational arrangement is determined. From there, we will turn our attention to items affecting your place of assignment and the training requirements you might receive while under a POMO type of aircraft maintenance concept.

053a (Objective 102—for computer answer key and feedback reference only). Explain factors related to set-up and development of a maintenance program established under a POMO concept.

The POMO is a concept that reorganizes maintenance activities by major tasks to support each flying squadron. In other words, it is the formalization of the type of maintenance operation that develops in a combat situation. How this is accomplished can be easily understood by examining the basic maintenance concept of maintenance production and the organizational arrangement related to POMO.

Maintenance Production. A maintenance program, whether developed under AFM 66-1 or AFR 66-5, is primarily concerned with doing the maintenance required and providing the basic data inputs for maintenance engineering decisions. Activities related to these two concerns are collectively called Maintenance Production. Maintenance Production is servicing, repairing, testing, overhauling, modifying, calibrating, converting, and inspecting aircraft. Under the POMO maintenance concept, these work activities are divided into two categories: on-equipment and off-equipment.

On-equipment category. On-equipment aircraft maintenance normally consists of inspecting, servicing, lubricating, adjusting, and replacing parts, assemblies, and subassemblies. These types of work activities are accomplished at the aircraft—on the flight line.

Off-equipment category. Off-equipment aircraft maintenance normally consists of in-shop calibrating, repairing, or replacing of damaged or unserviceable parts, components or assemblies; modifying materials; emergency manufacturing of unavailable parts; and providing technical assistance to the using organizations. The words "in-shop" are the ones that separate these work activities from the on-equipment category.

Under the POMO concept, personnel are arranged into "off- and on"-aircraft production groups. These will be easily seen as we look at the organizational structure under an ideal POMO situation.

Organizational Arrangement—POMO. The organizational arrangement of a POMO concept consists of three main squadrons or production groups. These production groups are the Aircraft Generation Squadron (AGS), the Component Repair Squadron (CRS), and the Equipment Maintenance Squadron (EMS). Figure 4-2A shows an overview and the relationship of the various parts of a POMO. What each of these squadrons is required to accomplish is directly related to the category of maintenance it is responsible for.

Aircraft Generation Squadron (AGS). The AGS is primarily concerned with on-equipment maintenance and is arranged into branches which are largely self-sufficient. Figure 4-2B show the usual organizational arrangement. In the AGS of tactical fighter/reconnaissance wings, the flight-line activity will be organized in Aircraft Maintenance Units (AMUs). The number of AMUs in the flight-line activity will be the same as the number of flying squadrons assigned to the wing. The objective is to foster rapport between aircrew members and maintenance people, and to encourage more maintenance identification with the flying mission.

Component Repair Squadron (CRS). The CRS primarily accomplishes off-equipment repairs of aircraft and support equipment components. This squadron takes care of the maintenance beyond the capability of the AGS and the EMS. Additional tasks accomplished are fabrication of parts, maintenance and operation of aircrew training devices, and repair and calibration of precision measurement equipment. This squadron is functionally divided into three branches: Propulsion Avionics, Accessory Maintenance, and the Precision Measurement Equipment Laboratory (see fig. 4-2C).

Equipment Maintenance Squadron (EMS). The EMS is responsible for the off-equipment maintenance of powered AGE (support equipment) and selected aircraft components and extensive on-equipment maintenance of aircraft and AGE. Figure 4-2D show the location of the specific shops within the three branches.

Exercises (053a):

1. How are maintenance activities under POMO organized?

2. How are the categories of maintenance activities determined for the maintenance production concept under POMO?

3. How are the maintenance squadrons developed under the categories of equipment maintenance?

4. Why are individual specialists assigned to specific AMUs within an AGS?

5. How are the functional areas of responsibility arranged within the CRS?

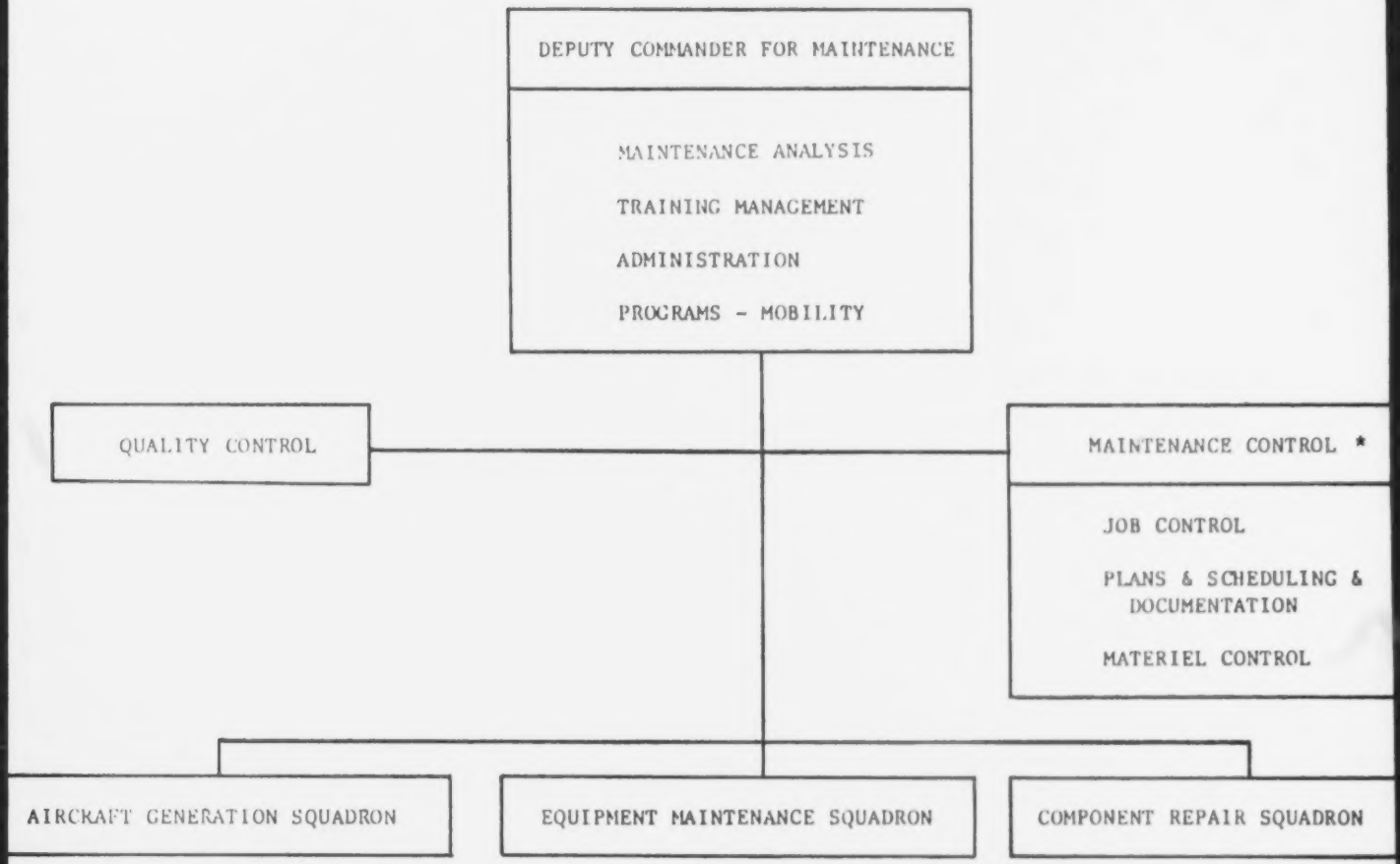
053b (Objective 103—for computer answer key and feedback reference only). Point out selected characteristics of the areas of assignment and types of additional training you as an airframe repairman might receive under POMO.

When you work under AFM 66-1 as an airframe repairman, you are assigned to only one area—the structural repair shop within the fabrication branch of the field maintenance squadron (review fig. 4-2). Also, the only formal training you received is that associated with upgrade training—going to a 5 or 7 skill level. But this is not the case when you work under AFR 66-5, as you will quickly see as we look at the possible areas of assignment and the additional types of training you can receive under a POMO concept.

Areas of Assignments. Under a POMO type of maintenance situation, you as an airframe repairman can be assigned to either the Aircraft Generation Squadron or the Component Repair Squadron. When assigned to AGS, you will be placed in a specialist flight section within a specific aircraft maintenance unit (refer to fig. 4-2B). This specialist flight section will contain a number of different AFSC specialists working out of one central location. Under this type of arrangement, the extent of your airframe repair maintenance will be limited to only minor on-equipment repairs because you will not be working out of a structural repair shop environment. However, there might be times when you will be called upon to support the Equipment Maintenance Squadron when extensive on-equipment structural repairs are needed.

When assigned to Component Repair Squadron, you will be placed in the structural repair shop within the Accessory Maintenance Branch (review fig. 4-2C). This environment is directly opposite from that of the specialist flight section. In the CRS set-up, you work primarily in a shop area and repair mainly off-equipment items. However, there might be times when you will be called upon to support either an AGU or the EMS.

Types of Training Requirments. The type and amount of training you will receive depend on your squadron of assignment within a POMO arrangement. If you are assigned to CRS, your training would



* May include Munitions Control

Figure 4-2A. Deputy Commander for Maintenance (POMO).

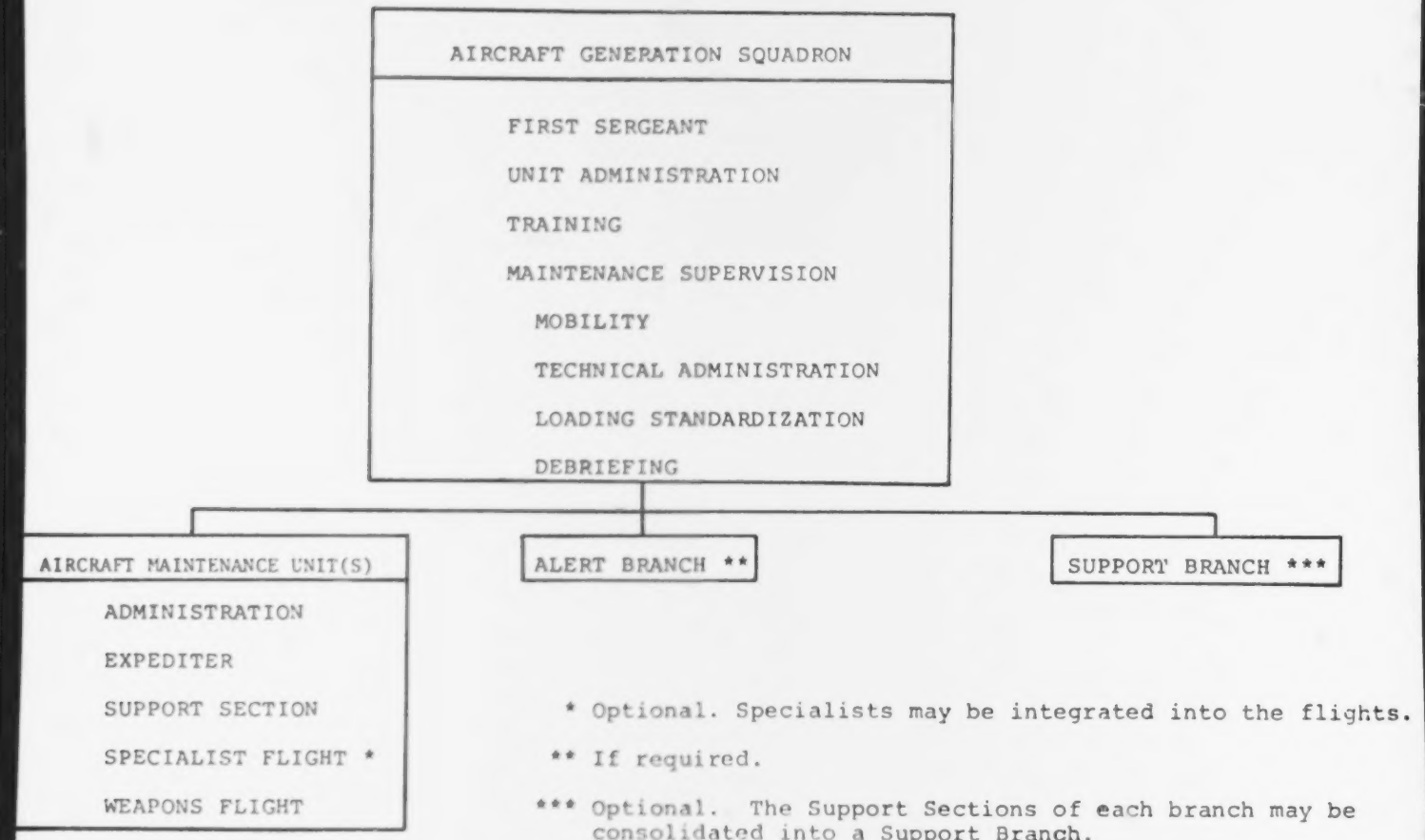
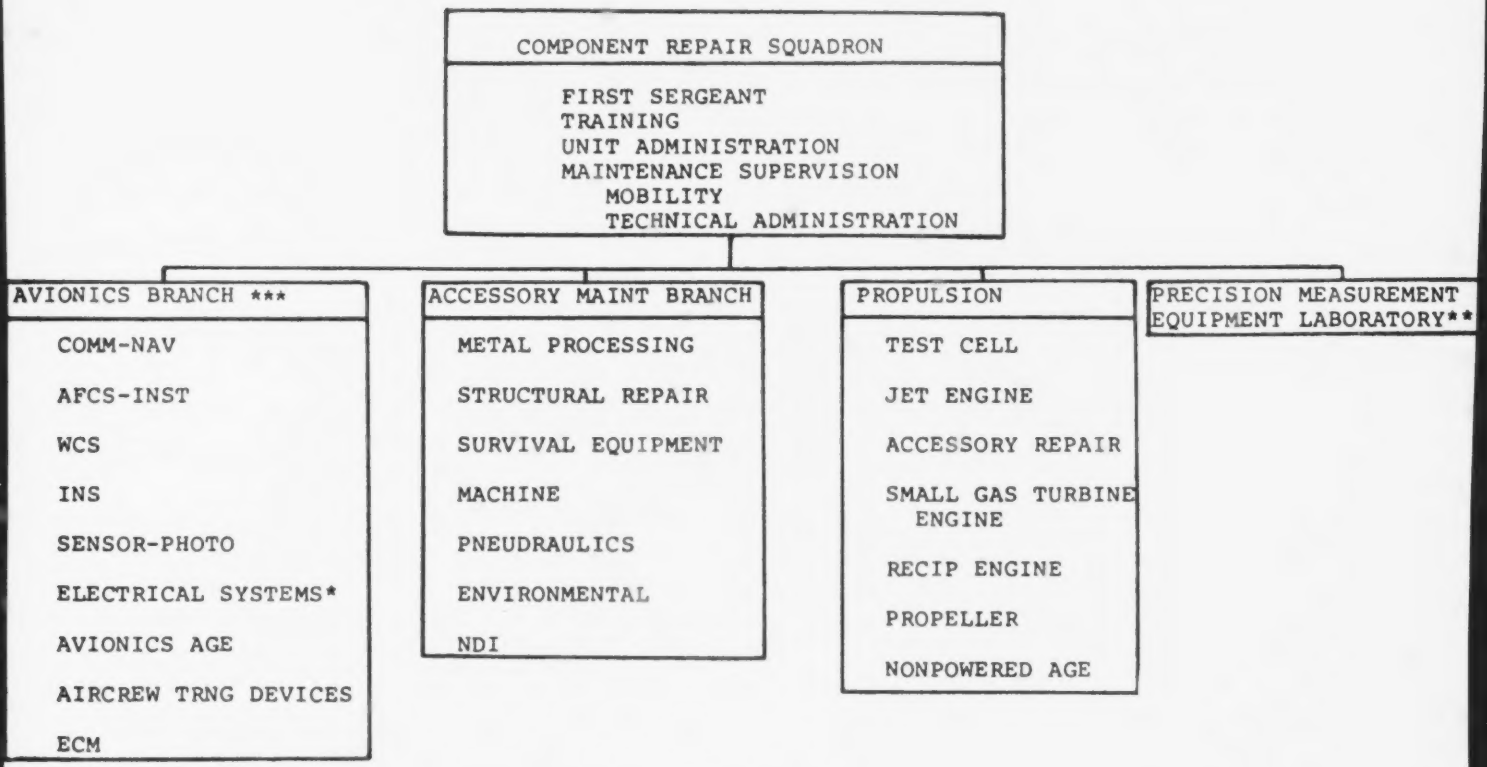


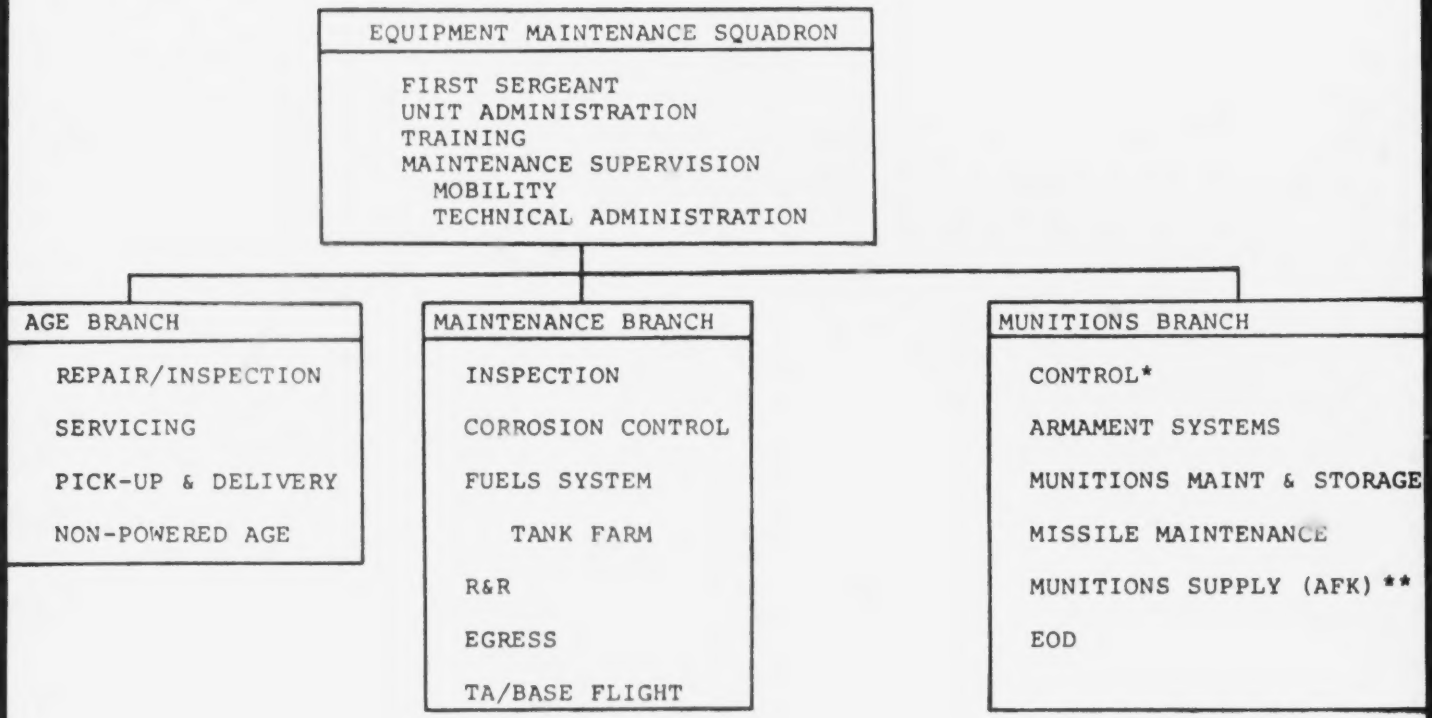
Figure 4-2B. Aircraft Generation Squadron.



* May be located in the Acessory Maintenance Branch (as determined by the MAJCOM/LGM)

** May be consolidated with the Avionics Branch

Figure 4-2C. Component Repair Squadron.



* May be consolidated with Maintenance Control.

** May be placed under Squadron Commander at MAJCOM option.

Figure 4-2D. Equipment Maintenance Squadron.

normally be limited upgrade (skill level) requirements conducted within the structural repair shop. If, on the other hand, you are assigned to the AGS, you would not only receive the normal upgrade (skill level) training, but also the training conducted as either cross-utilization training (CUT) or assist task qualification training.

Cross-utilization training. CUT is the training necessary to provide you with the ability to perform selected tasks in a closely related AFSC. Your training will be conducted to the 2,b proficiency level (review fig. 1-2) as reflected on a specially developed cross-utilization specialty STS. This training will consist of practical training and may include training conducted by the field training detachment (FTO).

Assist task qualification training. This training is necessary to provide you with the ability to assist other maintenance technicians in the performance of selected tasks. In other words, when you are not doing airframe repair work, you will be helping people in their jobs. Not only must you be a qualified airframe repairman, you will also be called upon to perform aircraft general type tasks such as:

- Launch/recovery.
- Towing.
- Wash.
- Refuel/defuel.
- Jacking
- Installation/removal of external stores.

This assist task qualification training will train you to the 2,b level for selected tasks. However, you can be trained to a higher level if necessary. This training will consist of practical training and may include training conducted by FTO units.

NOTE: Regardless of the type of training you receive, always be sure that it is documented on your training records. This prevents duplication of training and permits proper utilization of people.

Exercises (053b):

1. Indicate the type of maintenance and work environment you as an airframe repairman will have when assigned to AGS.

2. Indicate the type of maintenance and work environment you as an airframe repairman will have when assigned to CRS.

3. What factor determines the types of training you receive under POMO?

4. Indicate the training you will receive when assigned to an AGS.

5. Indicate the training you will receive when assigned to CRS.

4-2. Aircraft Inspection and Maintenance Systems

To keep aircraft as safe as humanly possible, the Air Force has developed a system of maintenance and inspection that is considered to be the finest in the world. This system is continually undergoing improvement. The aircraft is not only examined for sources of possible malfunctions; in addition, discrepancies which are detected are immediately repaired. Records are kept and analyzed to provide data for further improvement of the system.

In keeping with our discussion of maintenance, let's turn our attention to the systems used to accomplish maintenance, particularly the inspection system.

054. State the three levels of maintenance, and characterize the maintenance accomplished at each level.

Levels of Maintenance. The three levels of maintenance from lowest to highest are: organizational, intermediate, and depot. The overall maintenance and inspection policies are formulated by Air Force Logistics Command (AFLC). To support all Air Force organizations AFLC has established air logistics centers that are charged with depot class maintenance.

The major commands engaged in actual flight-line operations are divided into numbered Air Forces and divisions. An air division is further divided into wings, which are normally the smallest self-sufficient units.

Organizational maintenance. Organizational maintenance is limited in scope. This level of maintenance includes routine inspections, replacement of some components, minor structural repairs, and servicing with fuel, oil, etc. Organizational maintenance may also perform technical order modifications that can be performed with the facilities available at the organizational level.

It is of the utmost importance that technicians at organizational level discover indications of equipment failure soon enough to prevent major component failure. Failure to discover these indications results in an increase in the workload of other levels of

maintenance. This may result in disruption of maintenance schedules, not to mention in-flight failure with the possibility of loss of life and equipment.

Intermediate maintenance. Closely supporting the organizational level of maintenance is the intermediate level of maintenance. Personnel in the field maintenance activity, usually a field maintenance squadron (FMS), perform maintenance at the intermediate level. The FMS usually has the highest concentration of skilled specialists and costly equipment in the maintenance organization. You will find such shops as engines, fuel systems, electrical, pneudraulics, and egress—just to name a few—at this level. The actual number will de-

Exercises (086):

1. What determines which type of TCTO is published?

2. How is an interim TCTO issued?

3. List the symbols used to identify the types of TCTOs.

4. What is the difference between a routine action category 1 TCTO and a routine action category 2 TCTO?

5. When is a red X entered in the aircraft maintenance forms (781A) for an Urgent Action TCTO?

Exercises (087):

1. Who is responsible for establishing a control section to handle TCTOs within a maintenance organization?

2. Why are Immediate Action TCTOs not delayed because of nonavilability of kits?

3. What system is used to determine who receives TCTO kits first?

4. How are AFTO Forms 349 used for TCTO maintenance actions sometimes distinguished from other AFTO Forms 349?

5. What action should be taken if a part of a TCTO is missing?

087. Point out how TCTO kits are used and controlled.

TCTO Kits. Since some TCTOs require the use of TCTO kits, our coverage of TCTOs is not complete without a discussion of these kits.

Kit policies. Immediate action TCTOs are released upon determination of a requirement for a technical order. Release is not delayed pending availability of the kits.

Urgent action and routine action TCTOs are released upon availability of the first kits or parts. Kits are distributed to Air Force activities by priority. One copy of the applicable TCTO is packaged with each kit. These copies are identical to the same-dated copies distributed for files and, therefore, are completely authoritative for compliance. The format used for TCTOs is shown in figure 5-10. Little is left for misinterpretation. All areas of responsibilities are included.

Kit control. A technical order compliance control will be established by the Deputy Commander for Maintenance, preferably in the maintenance control section. They will administer the TCTO records and control of kit distribution as required by maintenance activities. Green colored AFTO Forms 349 may be used to identify maintenance actions accomplished relative to TCTOs.

Incomplete kits will be returned immediately upon determination of shortage to the TCTO control point. They, in-turn, contact supply for corrective action.

5-3. Maintenance of Technical Orders

Technical orders are a very necessary and vital part of your daily work. It is extremely important that the TOs you are using are up to date. Many a maintenance person has met his/her "Waterloo" by not using an up-to-date technical order. Right now, someone is maintaining our shop's TOs to insure that this doesn't happen to you. Sooner or later you will be placed in this position, and many people will be depending upon you. How well you accomplish this job will directly affect the operation of your shop. In this section, we'll discuss the methods and procedures used to insure that technical orders are maintained in an up-to-date status.

087a (Objective 104—for computer answer key and feedback reference only). Cite specific factors related to the set-up of an operational technical order file.

Each airframe repair shop has a technical order file. Technical orders relating to assigned aircraft and shop equipment, and other essential technical data reference publications are contained within this file. Instructions for maintaining this file are outlined in TO 00-5-2, *Technical Order Distribution System.* TO 00-5-2 classifies this shop file as an operational file.

Operational File. This type of file is located in operational and maintenance organizations. Each of the shops within a field maintenance squadron maintains this type of TO file.

Such files contain only the TOs required to accomplish the operational and maintenance responsibilities of the activities they serve—in other words, only what is needed to get the job done. They will be located for convenient, immediate reference by all using personnel. The Quality Control Section of the maintenance organization also maintains an organizational file, but on a much larger scale in that all TOs used within the entire maintenance complex are kept on file. Your shop file is a subaccount of the Quality Control file.

File Maintenance. The placement of technical orders within a shop file is not a "hit or miss" affair. Certain guidelines must be followed to insure that a needed TO can be located quickly or the present status (where the TO is and who has it) can be determined without waste of valuable time.

TO binders. The standard size (8¼ x 10¾ inches) technical orders are the ones you will most often work with. They are filed in a two-piece expandable type of binder which allows more than one TO to be filed within a single binder. Another TO binder you will occasionally use is the six-ring flexible cover type. The work unit code manuals are filed in this type of TO binder, usually only one TO to a binder. You will have a work unit code manual for each type aircraft assigned to your base.

Filing sequence. TOs are filed within the binders in a numerical sequence, lowest to highest number, in the same order that they are listed in the current NI&RTs, *(Numerical Index and Requirement Tables).* It's always best to check the latest NI&RT if you are unsure of the proper filing sequence.

Commercial publications authorized for USAF use and having a TO number assigned are placed in numerical order along with other TOs. File the identifying title page sheet in front of the publication that it identifies. If, for some reason, such as size, it is not practical to file commercial manuals in standard TO binders, you may file the title page in the TO file and make a notation on it, indicating the location of the manual.

For identification purposes you must insure that all standard binders in your file have a label (AFTO Form 32) attached to the bound side. The label (see fig. 5-9A) must contain the following minimum information:

- Book number, beginning with 1, to indicate the sequence in the particular file.
- The number of the first TO in the binder under "publication number FROM."
- The number of the last TO in the binder under "publication number THRU."

For identification of the work unit code manuals, labels will be attached to the bound side of the binder. Follow the same format outlined for the standard TO binders. Information on the ID labels for both the standard and nonstandard binder may be either printed by hand or typed.

NOTE: For optional variations in TO labeling, consult TO 00-5-2.

Exercises (087a):

1. What publication should you read to find out specific details for maintaining an operational TO file?

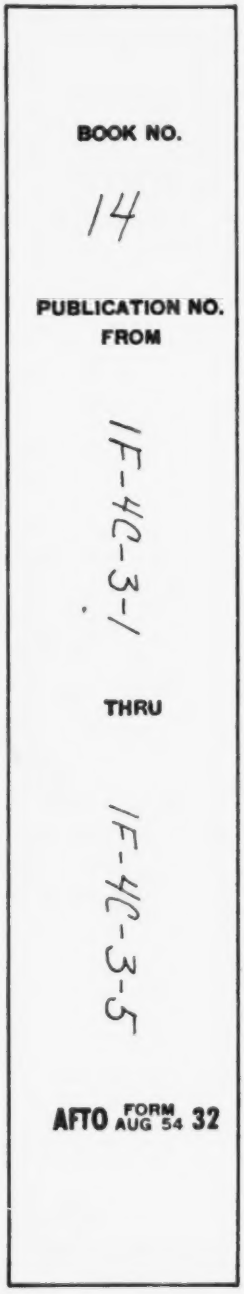


Figure 5-9A. AFTO Form 32.

2. Where should an operational TO file be located?

3. What determines the TOs that will be included in an operational file?

4. In what sequence are TOs filed?

5. What is the minimum information required on a new AFTO Form 32, that will be placed on a binder?

6. Assume that you receive a 5 x 8 inch commercial manual with a TO identifying title page and you wish to file it in a place other than the TO file because of its size. What action should you take concerning the TO file?

087b (Objective 105—for computer answer key and feedback reference only). Differentiate between TO requisition and initial distribution and arrange requisition and issue steps in their proper sequences.

You may obtain TOs for your shop file through "initial distribution" or by separate requisition. The two systems are different, and each serves its specific purposes.

Initial Distribution. Technical orders that are to be used on a day-to-day basis are ordered through the initial distribution system. This system is designed to provide you with the basic TO—plus changes, supplements, and revisions—as soon as possible after initial printing is completed. All you need to place your file on initial distribution for a TO is for the TO to be listed in the NI&RT and for you to have a legitimate reason for having the TO in your file. If the NI&RT lists the TO without a print date, it means that requirements for the TO have been established but the TO has not yet been printed. Should you order a TO in this way for initial distribution, your copies will be forwarded after printing is completed. After initial distribution, any changes, supplements, or revisions to the TO will be automatically sent to you as soon as they are printed, so you need not order them. If on the other hand, you go initial distribution for a TO already in print, your initial distribution will come complete with all changes and supplements. Any future changes, supplements or revisions will then be sent to you automatically.

Requisition. If you must order a TO on a one-time basis, you should use the requisition system. Examples of how you might use the requisition system are obtaining TOs for training purposes (one-time use) or replacing copies in your file that have become lost or damaged. To requisition a TO you must have a need for it, and it must be listed in the NI&RT with a published date. Technical orders listed in the NI&RT without a date cannot be obtained through the requisition system unless official distribution is known to have been made.

Ordering System. Now that we've looked at both methods of obtaining required technical orders, let's follow the path a TO request takes and see exactly where it goes.

Your shop file is probably a subaccount of the master file maintained in Quality Control. You therefore make your TO requirements known to the individual responsible for maintaining the QC file. He will certify your requests, consolidate them with requests from other shops within the maintenance organization, and forward the requests to the Base Technical Order Distribution Office (TODO). The base TODO then will certify these requests, consolidate them with requests from other organizations on base, and transcribe the consolidated requests to key punchcards. They will then take the punchcards to the base telecommunications facility, where they are used for input to the Automatic Digital Network (AUTODIN). The requests are transmitted by AUTODIN to Oklahome City Air Logistics Center (OCALC). Upon receipt of the requirements from TODOs, OCALC estabishes the requirements in the TO computer system.

Each air logistics center or printer, upon receipt of machine requisitions or initial distribution instructions from OCALC, ships the TOs to the various TODOs. Your base TODO then forwards TOs to each organization, including the QC account, of which yours is a subaccount. The QC account will then forward your TOs to you. Figure 5-9B depicts the sequence of events just covered.

Exercises (087b):

1. In each of the following situations, match the ordering system to the situation by placing "REQ" in the block provided for requisition or "ID" for initial distribution:

_____ a. Your shop received a new piece of equipment and you need TOs to operate and maintain the equipment.

_____ b. You find several pages missing from a TO in your file and you want to order a new copy to replace it.

_____ c. Your copy of TO 1B-52D-3-1 is missing from the file and you must order another copy.

_____ d. You are notified that your base is receiving a squadron of F-15 aircraft which will be stationed here indefinitely and you should order all applicable TOs.

2. Place the following events in a TO requisition and issue cycle in the proper order by numbering them in the sequence that they occur:

_____ a. TODO consolidates and certifies requests and forwards them to Oklahoma City ALC.

_____ b. You initiate and submit your TO request to the QC TO file of which you are a subaccount.

_____ c. Oklahoma City ALC establishes the requirements in the TO computer system.

_____ d. The responsible ALC or printer ships the TOs to your base TODO.

_____ e. The QC file account representative forwards your TO to you.

_____ f. The base TODO forwards your TO to the QC TO file account representative.

_____ g. The QC file custodian consolidates requests and forwards them to TODO.

087c (Objective 106—for computer answer key and feedback reference only). Given situations related to routine TO action requests involving the use of an AFTO Form 187, Part I, make the required entries.

Now that you know what systems are used to obtain technical orders, let's take a close look at how you get involved with these systems. TO action requests such as ordering new TOs either for replacement of on-file

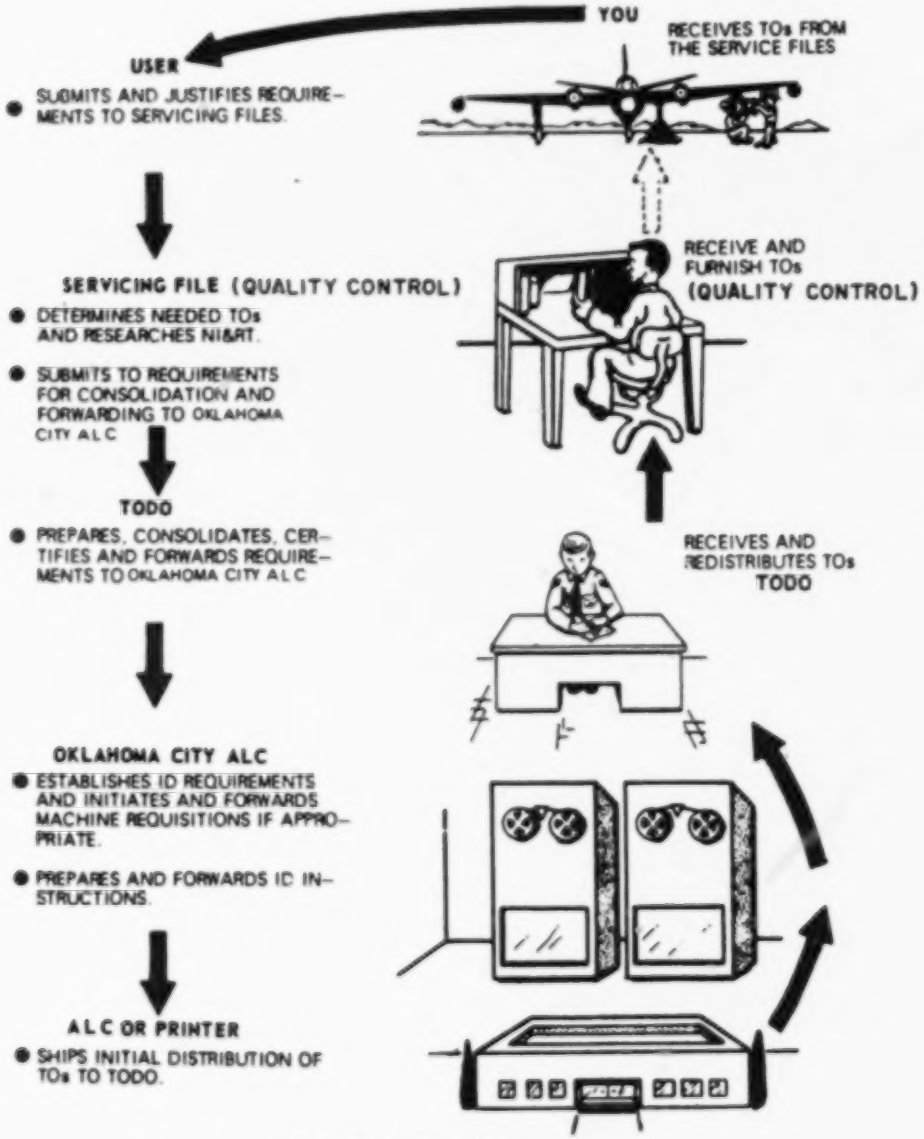

YOU
RECEIVES TOs FROM THE SERVICE FILES
USER
SUBMITS AND JUSTIFIES REQUIREMENTS TO SERVICING FILES.
RECEIVE AND FURNISH TOs (QUALITY CONTROL)
SERVICING FILE (QUALITY CONTROL)
DETERMINES NEEDED TOs AND RESEARCHES NI&RT.
SUBMITS TO REQUIREMENTS FOR CONSOLIDATION AND FORWARDING TO OKLAHOMA CITY ALC
RECEIVES AND REDISTRIBUTES TOs TODO
TODO
PREPARES, CONSOLIDATES, CERTIFIES AND FORWARDS REQUIREMENTS TO OKLAHOMA CITY ALC
OKLAHOMA CITY ALC
ESTABLISHES ID REQUIREMENTS AND INITIATES AND FORWARDS MACHINE REQUISITIONS IF APPROPRIATE.
PREPARES AND FORWARDS ID INSTRUCTIONS.
ALC OR PRINTER
SHIPS INITIAL DISTRIBUTION OF TOs TO TODO.

Figure 5-9B. TO requisitioning sequence.

TODO/TECHNICAL ORDER PUBLICATIONS REQUIREMENT TABLE

DATA MESSAGEFORM INFORMATION	PRECEDENCE	LMF CC	CLASSIFICATION
ADDRESSEE (Clear Text)			CARD COUNT (Detail Cards)
ORIGINATOR'S IDENTIFICATION (RCS, Follow-up, Status, etc.) TO REQUIREMENTS	CONTENT IND	RELEASING OFFICER'S SIGNATURE	ORGN CODE – EXT

REMARKS

Complete above only for submission of TODO 'TO Requirements, IAW 00-5-2, by AUTODIN to OCAMA (not applicable to MAP Codes).

DO NOT MAIL AS IS: Enclose This Form in Envelope, Address To: OCAMA/MMSUB Tinker AFB OK 73145

TO DISTRIBUTION CODE NUMBER (Col 1–4) AS ASSIGNED BY OCAMA: 0236-19

TO DISTRIBUTION CODE ADDRESS (Exactly as established with OCAMA)

NOTE: If address has changed submit revised AFTO Form 43.

DATE RETURNED (Col 5-40) YR	MO	DAY	TODO REQ NO. (Col 11-15)
78	01	10	00011

I certify that the requirements herein are the minimum essential requirements to support the mission of all organizations served by this distribution code. Requirements are approved IAW provisions of T O 00-5-2 and supplements thereto:

Harold Madison MSgt TODAR

Requisitioning Officer (Signature, Title, Grade)

Approved For Release (USAF 'United States Government Approving Agency, IAW T O 00-5-2: The approving agency has authority in accordance with applicable U.S. Air Force 'United States Government regulations (including regulations pertaining to release of classified military information) and authorizes release of the requested publications to the designated code and address.

Applicable to Specialized Codes, see T O 00-5-2.

USAF 'United States Government Approving Officer (Signature, Title, Grade)

PART I TODO REQUIREMENT

NOTE: Complete IAW T O 00-5-2, check TO number, security classification and special control carefully.

	TECHNICAL ORDER NUMBER (16–40)	CLAS (41)	(42)	INITIAL DISTRIBUTION QUANTITY (43–46)	ONE TIME REQUISITION QNTY (47–50)	COL (79)	COL (80)
A.	1F-4D-3-1	U		0003	0002	1	H
B	1F-15A-3	U		0001	0000	1	H
C	1B-52D-3	U		0003		1	H
D	1F-105F-3	U		XXXX		1	H
E	1C-141A-3	U			0001	1	H
						1	H
						1	H
						1	H
						1	H
						1	H
						1	H
						1	H
						1	H

KEYPUNCH – CHECK FOR KEYPUNCH DATA ON REVERSE SIDE

AFTO FORM APR 69 187 Replaces AFTO Form 213, Which Is Obsolete AFLC–WPAFB–JUL. 72 1200000

Figure 5-9C. AFTO Form 187 (front side).

PART II — TODO BACK ORDER CANCELLATION (See TO 00-5-2)

TECHNICAL ORDER NUMBER (16 – 40)	CLAS (41)	(42)	QUANTITY (47 – 50)	ORIGINAL REQ DATE (51 – 56)	ORIGINAL REQ NO. (58 – 62)	COL (78)	COL (79)	COL (80)
1C-130B-3	U		0002	14JAN 77	00025	C	1	Z
						C	1	Z
						C	1	Z
						C	1	Z

PART III — TODO REQUISITION FOLLOW – UP (See TO 00-5-2)

TECHNICAL ORDER NUMBER (16 – 40)	CLAS (41)	(42)	QUANTITY (47 – 50)	ORIGINAL REQ DATE (51 – 56)	FOL - UP DATA (57)	ORIGINAL REQ NUMBER (58 – 62)	COL (79)	COL (80)
1C-141A-3	U		0001	10JAN 78		00011	2	H
							2	H
							2	H
							2	H

Figure 5-9D. AFTO Form 187 (back side).

TOs or for training purposes, increasing or decreasing your initial distribution requirement, and if the need be, completely canceling an initial distribution requirement are how you will be involved most of the time. But before we take a look at these functions, let's first examine the AFTO Form 187 which is used for these and other technical order management functions.

AFTO Form 187. The AFTO Form 187, TODO/Technical Order Publications Requirement Table, is the form you will use for TO action requests between you and the master file (main TO account) in Quality Control. Upon receiving your AFTO Form 187, Quality Control will consolidate your request, along with any other requests from the maintenance shops, onto an AFTO Form 187 prior to sending it forward to TODO. TODO repeats the consolidation of AFTO Forms 187 again prior to transmitting the single request to OCALC.

AFTO Form 187, figures 5-9C and 5-9D, is divided into four main sections. The first section, "Data Messageform Information (top half of the front side of the form), is used mainly in conjunction with TODOs AUTODIN messages. TODO will take care of most of the entries within this section. Your input to this section is limited to filling in your subaccount code number and certifying your request by signing the "Requisitioning Officer" block.

NOTE: TODAR in the signature block, figure 5-9C, is the acronym for "Technical Order Distribution Account Representative."

The remaining three sections, labeled Parts I, II, and III, are the areas that concern you most. Each part is designed to serve a particular function or functions based on the entries you make within it. For the moment our attention will be focused only onPart I of the AFTO Form 187. In the next objective segment, we'll look at Parts II and III. It is within Part I that you will conduct most of the TO management functions dealing with routine TO action requests. Routine TO action requests are those activities associated with the day-to-day upkeep of a shop technical order file.

Part I, AFTO Form 187. It is extremely important that the entries you make are correct and that you fully understand the meanings of certain entries, especially those made in the Initial Distribution Quantity and One-Time Requisition Quantity columns. Incorrect entries will result in unnecessary delays (possible work stoppages), waste your time, waste the Air Force's money, and above all, lower the effectiveness of your shop to carry out its mission requirements.

When listing the technical order numbers (column 1 of Part I), always insure that the numbers are exactly the same as listed in the NI&RT. Also, when more than one TO is listed, list them in numerical sequence (lowest to highest). The classification code (column 2 of Part I) can also be obtained from the NI&RT. In most cases, you will be working with unclassified (U) technical orders. The last two columns, Initial Distribution Quantity and One-Time Requisition Quantity are the "key" columns. These are the ones by which you indicate what TO action request is needed.

Initial Distribution Changes. Let's assume that presently your TO file is on distribution for one copy of TO 1F-4D-3-1. You have a need to increase this requirement to three copies. The entries shown in line item "A" of Part I, figure 5-9C reflect this action request. The entry in the Initial Distribution Quantity column indicates to OCALC that you need only two copies of TO 1F-4D3-1 to bring your file up to the new initial distribution requirement level. If you didn't make this entry (0002), OCALC would automatically send you three copies, one of which you don't need. A point to remember here is that whatever entry you make in the Initial Distribution Quantity column is the final number of copies you will have in your file.

On the other hand, let's assume you wanted to decrease your presently authorized initial distribution requirements for TO 1F-15A-3 from three copies to one copy. The entries shown in line item "B," Part I,

figure 5-9C, reflect this TO action request. OCALC will automatically change your present initial distribution quantity to one. The four zeros in the One-Time Requirement Quantity column indicate to OCALC not to send any TOs because you have no need for them.

Starting or stopping initial distribution requirement. There are times when it is necessary to start or stop an initial distribution requirement. A change of assigned aircraft, receipt of a new piece of shop equipment, or even a change in the model series of your presently assigned aircraft will require these TO action requests.

Line item "C" of Part I in figure 5-9C shows the entry required to start a new initial distribution requirement for TO 1B-52D-3. The entry 0003 is the number of copies you need. No entry is made in the One-Time Requisition Quantity column because you need all three copies that OCALC will automatically send you.

The entry in line item "D" of Part I in figure 5-9C is for stopping a presently authorized distribution requirement level. The four Xs indicates to OCALC that you have no further need for this TO and want to cancel your present distribution requirement. No entry is made in the One-Time Requisition Quantity column.

Replacement technical orders. From time to time it is necessary to order replacement TOs for those already on initial distribution which have become worn, have pages missing, or are missing from your file. Also, sometimes it is necessary to order a specific TO to support a local training program. The entry you will make for either of these two purposes is shown in line item "E" of Part I in figure 5-9C. No entry is required in the Initial Distribution Quantity column, since your order is a one-time only TO action request. A point to remember here is that only current supplements, changes, etc., related to the TO ordered will be sent. You will not receive any future changes, supplements, etc.

NOTE: For TO management actions involving ordering technical orders under emergency or urgent conditions, consult TO 00-5-2 for procedures to follow.

Exercises (087c):

In each of the following situations, indicate the action you should take by making the appropriate entries on the front side of AFTO Form 187 in figure 5-9E. Assume that your TO account number is 0418-02 and the current date is 18 January 1978.

TODO/TECHNICAL ORDER PUBLICATIONS REQUIREMENT TABLE

DATA MESSAGEFORM INFORMATION	PRECEDENCE	LMF CC	CLASSIFICATION
ADDRESSEE (Clear Text)			CARD COUNT (Detail Cards)
ORIGINATOR'S IDENTIFICATION (ECS, Follow-up, Status, etc.)	CONTENT IND	RELEASING OFFICER'S SIGNATURE	Orgn CODE - EXY
TO REQUIREMENTS			
REMARKS			

Complete above only for submission of TODO/T O Requirements, IAW 00-5-2, by AUTODIN to Oklahoma City ALC (not applicable to MAP Codes).

DO NOT place in mail as is - mail to Oklahoma City ALC/MMEDUB, Tinker AFB, Ok, 73145, in envelope (See T O 00-5-2)	TO DISTRIBUTION CODE NUMBER (Col 1-4) AS ASSIGNED BY OKLAHOMA CITY ALC
T O DISTRIBUTION CODE ADDRESS (Exactly as established with Oklahoma City ALC)	DATE RETURNED (Col 5-10) YR MO DAY / TODO REQ NO. (Col 11-15)

NOTE: If address has changed submit revised AFTO Form 43

I certify that the requirements herein are the minimum essential requirements to support the mission of all organizations served by this distribution code. Requirements are approved IAW provisions of T O 00-5-2 and supplements thereto.

Requisitioning Officer (Signature, Title, Grade)

Approved For Release (USAF/United States Government Approving Agency, IAW T O 00-5-2)
The approving agency has authority in accordance with applicable U S Air Force/United States Government regulations (including regulations pertaining to release of classified military information) and authorizes release of the requested publications to the designated code and address.

Applicable to Specialized Codes, see T O 00-5-2

USAF/United States Government Approving Officer (Signature, Title, Grade)

PART I — TODO REQUIREMENT

NOTE: Complete IAW T O 00-5-2, check TO number, security classification and special control carefully.

TECHNICAL ORDER NUMBER (16-40)	CLAS (41)	(42)	INITIAL DISTRIBUTION QUANTITY (42-46)	ONE TIME REQUISITION QNTY (47-51)	COL (79)	COL (80)
					I	H
					I	H
					I	H
					I	H

Figure 5-9E. AFTO Form 187—front side (objective 087c, exercises 1-4).

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1. You notice that your file copy of TO 1-1A-8 is badly worn and has pages missing.

2. Because of an increase in the number of assigned aircraft, you need to increase your initial distribution of TO 1F-15E-3 from one to two copies.

3. With the replacement of F-4C aircraft with F-15 aircraft, you need to cancel your initial distribution requirement level for TO 1F-4C-3-1.

4. With the reduction of KC-135 aircraft assigned to your base, you need to reduce your initial distribution requirement level of TO 1C-135(K)-3-1 from three copies to one copy.

087d (Objective 107—for computer answer key and feedback reference only). Given situations involving the use of the AFTO Form 187, Parts II and III, make the required entries.

Besides the TO action request functions related to Part I of the AFTO Form 187 just covered, the remaining two parts of this form are also of interest to you. The TO actions requested in these two parts are not accomplished as often as those related to Part I, but are equally important to the overall effectiveness of your technical order management program.

Requisition Follow Up. If you do not receive an ordered technical order or notification of the reason for nonshipment within 60 days (90 days overseas) from the date you submitted your original request, you need to submit a requisition follow up. Part III of the AFTO Form 187 is what you use for this purpose. Follow ups will not be made unless the TOs involved are listed as published and current in the applicable NI&RT or official distribution is known to have been made prior to submission of the original requisition and proper procedures have been followed in requisitioning the TO.

Let's assume that your original request is the one shown in figure 5-9C. It was submitted on the 10th of January and you have not received TO 1C-141A-3 (line item "E" of Part I in fig. 5-9C) by 11 March. At this time you would submit an AFTO Form 187 with Part III (see fig. 5-9D) in the following manner:

(1) Enter the same information as shown in Part I for line item "E" (fig. 5-9C) in the same column indicated in Part III (technical order number, classification code, and quantity ordered).

(2) Enter the date of the original request in the original date required column.

(3) Enter the TODO request assigned to the original requisition in the original requisition number column.

NOTE: The sources of information needed for items (2) and (3) is found in the Date Messageform Information section of the original AFTO Form 187.

(4) Leave the "Followup Data" column blank if you are making a follow up on just the basic portion of a TO. When making a follow up for both the basic portions of the TO and its supplements, you need to enter the letter "A."

As for the necessary entries in Part I, you need only enter your subaccount code number and certify your request by signing the "Requisitioning Officer" blank. When this is completed, forward the AFTO Form 187 to the Quality Control TO section. They, in turn, will forward your followup inquiry.

If within 30 days after your followup inquiry you don't receive either the needed TO or an AFTO Form 215, TO Notification Form, notify your main account representative (Quality Control). Quality Control will notify TODO, which will notify the appropriate technical order distribution control activity (TODCA), in writing, giving all pertinent data.

Backorder Cancellation. If for some reason you have to cancel a technical order request which has been placed in a backorder status, you will fill out Part II of the AFTO Form 187. The backorder cancellation is prepared in the same manner as the requisition follow up, except that column 57 is not used. Figure 5-9D, Part II, shows an example of a backorder cancellation. The same sequence of processing the AFTO Form 187 is followed (from you to QC to TODO to OCALC).

Exercises (087d):

In the following situations, indicate the action you should take by making the appropriate entries in Parts II and III of the AFTO Form 187 in figure 5-9F.

PART II — TODO BACK ORDER CANCELLATION (See TO 00-5-2)								
TECHNICAL ORDER NUMBER (10 – 40)	CLAS (41)	(42)	QUANTITY (47 – 50)	ORIGINAL REQ DATE (51 – 56)	ORIGINAL REQ NO. (58 – 62)	COL (79)	COL (79)	COL (80)
						C	1	X
						C	1	X
						C	1	X
						C	1	X

PART III — TODO REQUISITION FOLLOW – UP (See TO 00-5-2)								
TECHNICAL ORDER NUMBER (10 – 40)	CLAS (41)	(42)	QUANTITY (47 – 50)	ORIGINAL REQ DATE (51 – 56)	FOLLOW UP DATA (57)	ORIGINAL REQ NUMBER (58 – 62)	COL (79)	COL (80)
							2	H
							2	H
							2	H
							2	H

Figure 5-9F. AFTO 187—back side (objective 087d, exercises 1 and 2).

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1. You notice that the replacement copy of TO 1-1A-8 that you ordered on 18 January 1978, request number 00033, has not been received and you have not received notification of the reason for the backorder.

2. Your F-4C aircraft are being replaced by F-15 aircraft. You have one copy of TO 1F-4C-4, *Illustrated Parts Breakdown*, backordered, request 00584 dated 30 December 1977. You need to cancel the request.

087e (Objective 108—for computer answer key and feedback reference only). Given situations involving TO requirements and distribution, make the appropriate entries on an AFTO Form 110.

As with any management system, whether maintenance repair actions, equipment utilization, or what have you, records must be kept. So it only stands to reason, a system of maintaining records for an effective technical order management program has been developed. This TO management record system is centered on the AFTO Form 110.

Whoever is responsible for the upkeep of your TO file is required to maintain an AFTO Form 110 file record of TO transactions. The use of the AFTO Form 110 is by far the best method of keeping the currency and accountability of your file from becoming unmanageable.

AFTO Form 110. The AFTO Form 110 is an 8- x 10-inch card printed on both sides, see figures 5-9G and 5-9H. This form is designed for filing in a three-ring binder; however, alternate filing methods are permitted. All entries on this form will be made by pencil to allow for up-dating corrections. The AFTO Form 110 records cards are filed by technical order number in alphameric order (lowest to highest number). A separate form is required for each technical order on file. As for technical order series (TCTOs), either a separate card is maintained for each TCTO or a separate card containing a complete series listing can be maintained.

The AFTO Form 110 record card file provides you with the following services:

- A record of all TOs required in your file.
- A record of all TOs received and maintained by you.
- An adequate record for inventory of TOs.
- A quick means of cross-checking current NI&RTs with maintained TOs.
- An aid when periodic inspections of your TO file are required.

Parts Breakdown. The AFTO Form 110 is divided into four parts. Parts I and II (fig. 5-9G) are on the front side of the form and Parts III and IV (fig. 5-9H) are on the back side. Each part serves a particular purpose, but each is interconnected in certain aspects, as you will see as we look at entries required in each part.

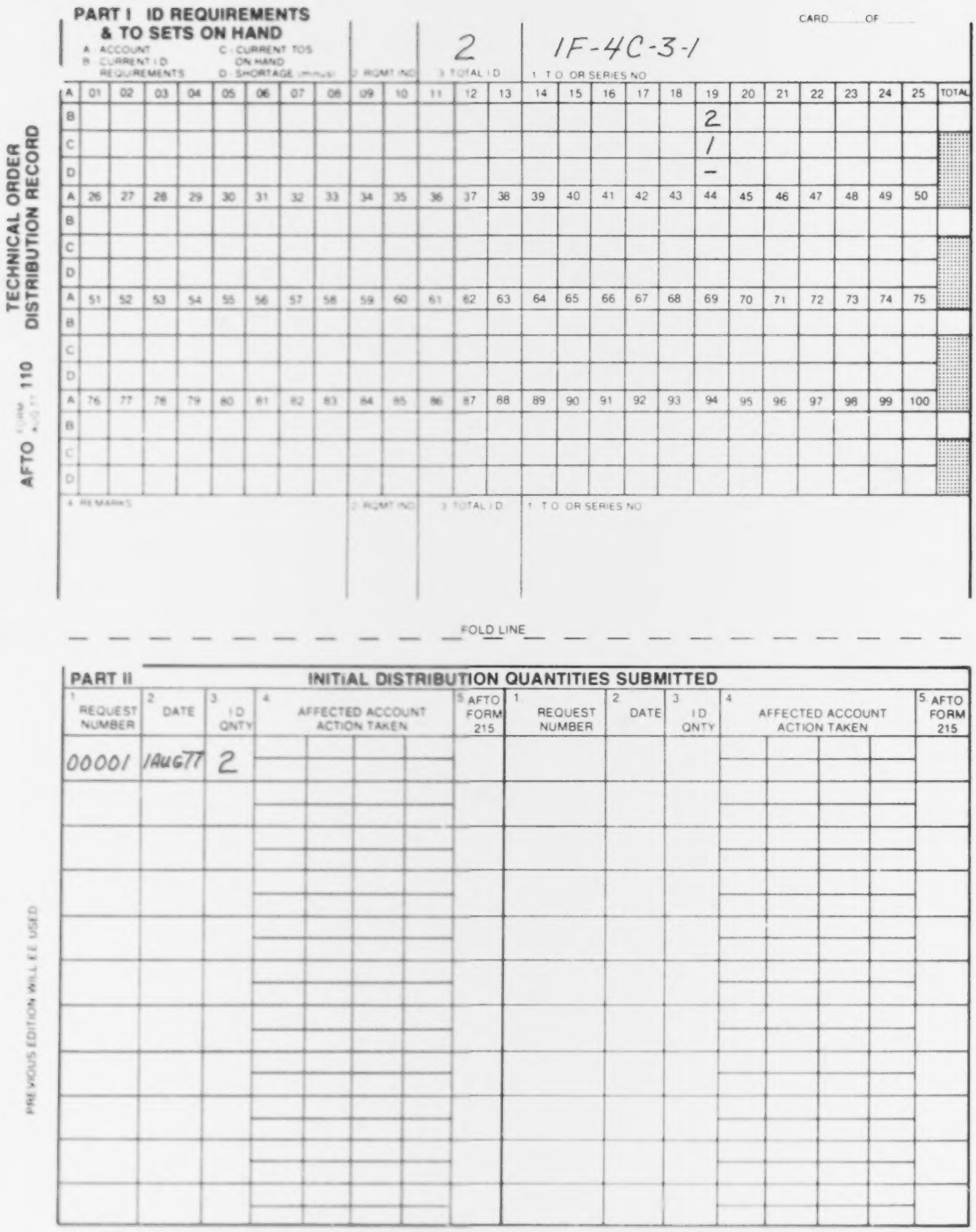
Part I, ID Requirements and TO Sets on Hand. Part I is filled out as shown in the upper portion of figure 5-9G. Block 1 identifies the applicable basic technical order or series number. The requirement indicator needed for block 2 is found in parentheses under the technical order number in the NI&RT listing. A requirement indicator is a letter(s) designator used to indicate the potential classification or restriction of the technical order. It is used instead of the actual classification. In situations involving unclassified TOs, which you will handle most often, block 2 is left blank. For higher levels of classification, consult TO 00-5-2 for the necessary requirement indicator. Block 3 indicates the total initial distribution requirements established for the technical order listed in block 1. Since it is unlikely that your technical order account will distribute TOs to other accounts, block 3 will reflect the number of copies of the TO you have in your file.

The small blocks number 01 through 100 are used to show your initial distribution requirement level, the actual number of copies you have on hand and the code identification number assigned to your file account. Figure 5-9G shows that the account number is 19 (line item "A") and is on distribution for two copies (line item "B") of TO 1F-4C-3-1. This account has one complete copy on hand (line item "C"). The minus sign in line item "D" shows that the basic, a revision, a change or a supplement, or some combination of this is missing from your file.

A legend explaining the line entries for lines A, B, C, and D is given in the upper left-hand corner of Part I. As for which set of blocks 1, 2, and 3 you fill out, it depends on the type of filing container you are using.

Part II, Initial Distribution Quantities Submitted. Part II, figure 5-9G, is documented to show both the establishment of initial distribution requirements and any changed requirements. Information needed for blocks 1, 2, and 3 can be obtained from the AFTO Form 187 used to establish your initial distribution requirement. The date required in block 2 is the date of the initial request, not the date of the technical order listed in block 1 of Part I. Since your account will most likely not distribute TOs, an entry in block 4 is not required. If your request for initial distribution request is backordered, then an entry is required in block 5. When a request is backordered, you will receive an AFTO Form 215. On the AFTO Form 215 is a *Notice* Code Indicator (reason for request being backordered) which you will enter in block 5. Definitions of these Notice Codes are contained in TO 00-5-2.

Part III, Initial Distribution Record. Part III, figure 5-9H, is to record the receipt of initial distribution requirements including supplements, changes, and revisions. The first line of block 1 indicates the basic technical order number. The remaining lines in block 1 are used to record any supplements, changes, and



TECHNICAL ORDER DISTRIBUTION RECORD

AFTO FORM 110

PART I ID REQUIREMENTS & TO SETS ON HAND

A: ACCOUNT
B: CURRENT I.D. REQUIREMENTS
C: CURRENT TOS ON HAND
D: SHORTAGE (minus)

CARD ____ OF ____

2 (3 TOTAL I.D.)

1F-4C-3-1 (1. T.O. OR SERIES NO.)

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	TOTAL
B																			2							
C																			1							
D																			–							
A	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	
B																										
C																										
D																										
A	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	
B																										
C																										
D																										
A	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	
B																										
C																										
D																										

4. REMARKS | 2. RQMT NO. | 3. TOTAL I.D. | 1. T.O. OR SERIES NO.

FOLD LINE

PART II INITIAL DISTRIBUTION QUANTITIES SUBMITTED

1 REQUEST NUMBER	2 DATE	3 I.D. QNTY	4 AFFECTED ACCOUNT ACTION TAKEN	5 AFTO FORM 215	1. REQUEST NUMBER	2 DATE	3 I.D. QNTY	4 AFFECTED ACCOUNT ACTION TAKEN	5 AFTO FORM 215
00001	1AUG77	2							

PREVIOUS EDITION WILL BE USED

Figure 5-9G. AFTO Form 110, Parts I and II.

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PART III — INITIAL DISTRIBUTION RECORD

1 TECHNICAL ORDER NO SUP CHG CHG NO OR REV	2 T O DATE	3 CLAS	4 QNTY RCVD	5 DISTR DATE	6 ACCOUNT AND QUANTITY SHORT	7 TOTAL SHORT	8 SHORTAGE RCVD DATE
1F-4C-3-1	15 MAR 77		1	15 APR 77	19 1	1	20 MAR 77
CHG # 1	15 MAY 77		2	5 JUNE 77			
-SS-1	15 JUNE 77		2	10 JULY 77			
-SS-2	15 JULY 77		2	4 AUG 77			

FOLD LINE

PART IV — REQUISITION DISTRIBUTION RECORD

1 TECHNICAL ORDER NUMBER	2 DATE OF RQN	3 REQUEST NUMBER	4 QUANTITY RQND	5 ACCOUNT AND QUANTITY REQUISITIONED	6 DATE RCVD	7 AMT RCVD	8 AFTO 215/221 RCVD
BASIC	15 AUG 77	00049	1	19 1	25 AUG 77	1	

Figure 5-9H. AFTO Form 110, Parts III and IV.

revisions related to the basic TO. Do not repeat the basic TO number when recording changes, supplements, or revisions received. Show only the suffixes used to represent the additional data received (see fig. 5-9H).

Block 2 shows the dates of the publications listed in block 1. An entry in block 3 is required only when the classification of a supplement or change is different from that of the basic technical order as indicated in block 2 of Part I. Appropriate entries in blocks 1, 2, and 3 will be lined out as publications listed are rescinded or replaced. Changes are lined out on receipt of a basic TO revision replacing them. Supplements are lined out when replaced by a change or revision to the basic TO or another supplement.

You will make entries in blocks 6, 7, and 8 when shortages in distribution occur. In figure 5-9H, the entries indicate that account number 19 is short one basic issue of TO-4C-3-1, and this shortage is as of 20 March 1977.

Part IV, Requisition Distribution Record. Part IV, figure 5-9H, is used to record one-time requisitions submitted and received. When you requisition a TO, entries are required in blocks 1 through 5. Entries required for requisitions are as follows:

Block 1—Do not enter the complete TO number. When a supplement or change is ordered, enter the appropriate suffixes (-S-1, -SS-2, CHG) followed by date of the publication. When ordering either a new or revised basic TO, enter the word "Basic" followed by the date of the publication.

Block 2—This is the date of the request.

Block 3—This entry indicates ID number assigned to your request.

Block 4—This shows the number of TOs ordered.

Block 5—This calls for your TO account number and number of TOs ordered.

Blocks 6, 7, and 8 are filled in when you receive some action based on your request. When the item ordered is received, enter the date received in block 6 and the amount received in block 7. When a request is backordered, place the Notice Code Indicator given on the AFTO Form 215 received in block 8.

Exercises (087e):

For each of the following transactions, make the appropriate entry in the AFTO Form 110, figures 5-9I (1) and (2). Assume that your account number is 0236-19. Use top portion of Part I for required entries.

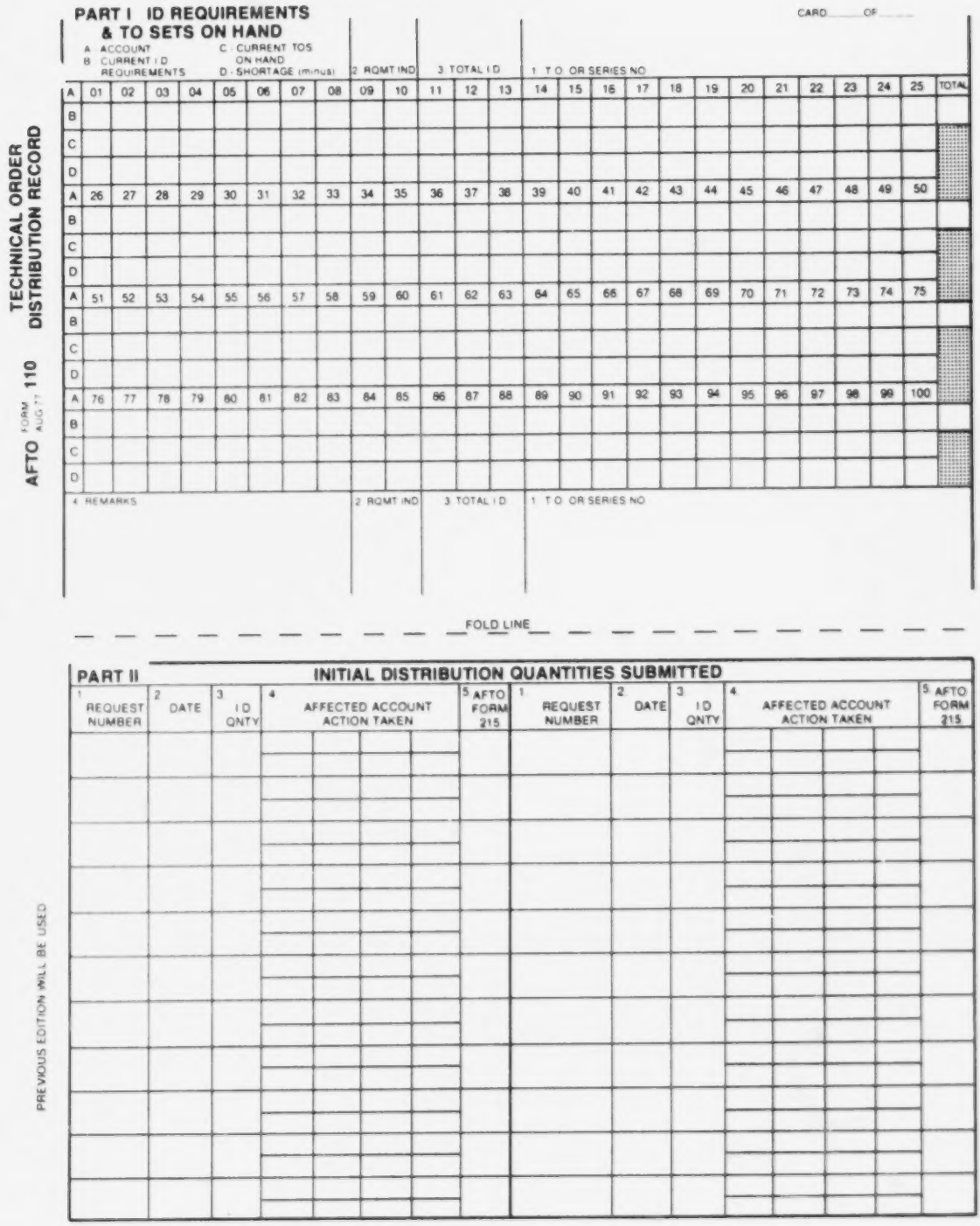

Figure 5-91 (1). AFTO Form 110, Parts I and II (objective 087e, exercises 1-5).

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PART III — **INITIAL DISTRIBUTION RECORD**

1. TECHNICAL ORDER NO. SUP/CHG/ CHG NO OR REV	2. T.O. DATE	3. CLAS	4. QNTY RCVD	5. DISTR DATE	6. ACCOUNT AND QUANTITY SHORT	7. TOTAL SHORT	8. SHORTAGE RCVD DATE

FOLD LINE

PART IV — **REQUISITION DISTRIBUTION RECORD**

1. TECHNICAL ORDER NUMBER	2. DATE OF RQN	3. REQUEST NUMBER	4. QUANTITY RQND	5. ACCOUNT AND QUANTITY REQUISITIONED	6. DATE RCVD	7. AMT RCVD	8. AFTO 215/ 221 RCVD

Figure 5-91 (2). AFTO Form 110, Parts III and IV (objective 087e, exercises 1-5).

1. You need to establish initial distribution for three copies of TO 1F-4C-3-1. This TO is unclassified and the basic date is 15 April 1974. The TODO request number is 00030 and it was requested 13 January 1977.

2. You received your three copies of TO 1F-4C-3-1 on 11 February 1977.

3. You received two copies of Change 1 to TO 1F-4C-3-1 dated 15 June 1977 on 26 June 1977 and ordered one copy of the Change to complete your file on the same day. The request number is 00037.

4. You receive your copy of Change 1 that you were short and also three copies of Supplement 1F-4C-3-15-7 on 8 August 1977. The date of the supplement is 22 July 1977.

5. On 17 December 1977, you receive three copies of Change 2 dated 1 November 1977. Change 2 replaces Supplement 1F-4C-3-15-7.

087f (Objective 109—for computer answer key and feedback reference only). Given situations related to TO file currency, state the action required.

To insure that your technical order file is maintained in a current status, you are required by TO 00-5-2 to make and document currency checks. These checks include the supplement and annual checks documented on the AFTO Form 131 and the 7-day and 180-day checks documented on AF Form 2411. Methods for accomplishing these required checks are discussed in the following paragraphs.

Supplement Check. Within 10 days after receiving an NI&RT revision or supplement, you must perform a supplement check of the 110s in your file for the TOs listed in the NI&RT.

Supplement checks consist of checking the AFTO Forms 110 against Part I and Part II listings in the NI&RT supplement or revision. You start with Part I, "New and Revised TOs," of the NI&RT. Locate the triple asterisk symbol (***) as shown in figure 5-9J. This symbol identifies new publications, revisions, or changes and listings of new supplements or new TCTOs. Check your 110s against these new and revised listings. Note and correct any discrepancies. The date of the publications shown on the AFTO Form 110, Part III, block 2, should be the same as, or a later date, than that shown in the NI&RT.

Missing or outdated publications indicated by this check must be annotated on the AFTO Form 110 and immediately requisitioned. Out-of-date, missing, or incomplete publications will have a minus symbol entered in line "D" of Part I on the AFTO Form 110.

Now check each TO number against the listing in Part II of the NI&RT as shown in the lower part of figure 5-9J. For technical orders listed as rescinded, renumbered, or canceled, enter the status above the TO number above block 1, Part I, of the AFTO Form 110. The AFTO Form 110, thus marked, should be tabled or otherwise identified. This form should be checked against the next issue of the NI&RT. If the TO is not listed, the TO and forms may then be destroyed.

When the basic TO on hand is the current issue and your TO file contains all the appendixes and supplements, and all are properly recorded, no annotation is reqiured on the AFTO Form 110.

Annual Check. The annual check is accomplished almost the same way the supplement checks are accomplished. The purpose of this check is to uncover deficiencies or excesses in your file which may have been overlooked during your supplement checks. Annual checks need not be made on all categories at one time. You are to determine a set schedule by TO category throughout the year. Once you have established the schedule, it should be followed each subsequent year.

The first step in the annual check involves a check between the current TO 0-1-01 and the NI&RT for the category you plan to check. This insures that the NI&RTs for the category are current and available. Next, using the NI&RTs, their supplements and the AFTO Form 110 for each TO in the category, insure the Part III entries on the AFTO Form 110 are current just as in the supplement check. Then check each individual TO from your file against its AFTO Form 110, Part III. Note and correct any discrepancies.

Documentation. Currency checks are documented on an AFTO Form 131. Prepare an AFTO Form 131 for each NI&RT and file them in NI&RT sequence in a three-ring binder labeled "Supplement and Annual NI&RT Inspection File." (Alternate filing methods are permitted.)

Refer to figure 5-9K for an example of an AFTO Form 131 filled out for NI&RT 0-1-02. Block 1 lists your TO file account number. Block 2 lists the NI&RT number. Blocks 3 through 9 are for recording inspections. Information recorded includes:

- Date of the basic NI&RT (3).
- Number and date of the supplements to the NI&RT (4 and 5).
- Date the check was completed (6).
- Whether the inspection was a supplement or annual check (7 or 8).
- Signature of the person completing the check (9).

When an AFTO Form 131 is filled, transcribe the last NI&RT supplement and annual check entries onto a new form.

A 180-Day Check. You must check each in-use and reference workcard deck, work unit code manual, and checklist for which you are responsible for currency at least each 180 days. You make this check by comparing the dates on the technical orders with the dates listed in the NI&RT. After you determine that the TO is current, check each page against the list of effective pages in the front of the TO. When this is done, document the check by making the necessary entries in the AFTO Form 2411 in figure 5-9L. Missing and out-of-date pages require requisitioning of replacement TOs.

A 7-Day Check. A supervisory inspection is required on each in-use inspection workcard deck, work unit code manual, and checklist to verify that changes and revisions were properly filed. The supervisor is notified through the weekly maintenance plan when new changes or revisions are received in the QC file. Within 7 days of the publication of the listing in the weekly maintenance plan, the new TO, change, or supplement

TO 0-1-01C

PART I

NEW AND REVISED PUBLISHED AND UNPUBLISHED TECHNICAL ORDERS

NUMERICAL INDEX AND REQUIREMENT TABLES

0-1-01 (U)	NUMERICAL INDEX AND REQUIREMENT TABLES, NUMERICAL INDEX, ALPHABETICAL INDEX, AND CROSS REFERENCE TABLE TECHNICAL ORDERS	30 JUN 76	OC
***0-1-01C	SUPPL--TITLE SAME AS BASIC	15 JUL 76	OC
0-1-02 (U)	GEN TECHNICAL ORDERS	20 FEB 76	OC
***0-1-02K	SUPPL--TITLE SAME AS BASIC	10 JUL 76	OC

PART II

RESCINDED, CANCELLED, REPLACED, RENUMBERED, RECLASSIFIED, AND DELETED TECHNICAL ORDERS

SECTION 1--RESCINDED TECHNICAL ORDERS
NO LISTING APPLICABLE IN THIS ISSUE

SECTION 2--CANCELLED TECHNICAL ORDERS
NO LISTING APPLICABLE IN THIS ISSUE

SECTION 3--REPLACED TECHNICAL ORDERS

GROUP 1--REPLACED TECHNICAL ORDERS IN THIS ISSUE

PUBLICATION NUMBER	REPLACED BY
0-1-02J DTD 14 JUN 76	0-1-02K DTD 10 JUL 76

GROUP 2--REPLACED TECHNICAL ORDERS IN PREVIOUS ISSUES
NO LISTING APPLICABLE IN THIS ISSUE

SECTION 4--RENUMBERED TECHNICAL ORDERS
NO LISTING APPLICABLE IN THIS ISSUE

SECTION 5--RECLASSIFIED TECHNICAL ORDERS
NO LISTING APPLICABLE IN THIS ISSUE

SECTION 6--DELETED TECHNICAL ORDERS
NO LISTING APPLICABLE IN THIS ISSUE

Figure 5-9J. NI&RT supplement.

For proper use of this form see TO 00-5-2 instructions.

1. TODO/TODA/TODS NUMBER: 0236-19

2. BASIC NI&RT NUMBER: 0-1-02

3. BASIC NI&RT DATE	SUPPLEMENT NI&RT 4. NUMBER	SUPPLEMENT NI&RT 5. DATE	6. DATE CHECK COMPLETED	7. ANNUAL	8. SUPPLEMENTS	9. CHECK COMPLETED (SIGNATURE)
9 Jul 75			20 Aug 75	L		J. Doebler
	0-1-02F	1 Apr 76	10 May 76		L	J. Doebler
	-02G	15 Apr 76	25 May 76		L	J. Doebler
	-02H	15 May 76	17 Jun 76		L	J. Doebler
	-02J	14 Jun 76	23 Jul 76		L	J. Doebler
20 Jul 76			24 AUG 76	V		J. Doebler

10. REMARKS

AFTO FORM 131

TECHNICAL ORDER NUMERICAL INDEX AND REQUIREMENT TABLE (NI&RT) SUPPLEMENTS AND ANNUAL CHECK

Figure 5-9K. AFTO Form 131.

INSPECTION DOCUMENT

FOR 00-25-06-2-2 QC-1-2

DATE OF INSPECTION	TYPE OF INSPECTION	LAST NAME OF INSPECTOR	DATE NEXT INSPECTION DUE	DATE OF INSPECTION	TYPE OF INSPECTION	LAST NAME OF INSPECTOR	DATE NEXT INSPECTION DUE
14-09-3	180 DAY	GALLAGHER	14-03-6				
14-03-6	180 DAY	COMBS	14-09-6				
31-08-6	180 DAY	DUSKEE	3-03-7				
06-09-6	7 DAY CK	COLLINS	NA				
2-01-7	7 DAY CK	COLLINS	NA				
3-03-7	180 DAY	DUSKEE	3-09-7				

AF FORM JUN 72 2411

Figure 5-9L. AF Form 2411.

must be filed and inspected by your supervisor. Look again at figure 5-9L. The basic TO listed in figure 5-9L was filed 31 August 1976 (third entry from the top), and the 180-day check was completed at the same time and rescheduled for 3 March 1977. The supervisor's 7-day check of this filing was completed 6 September 1976. The 7-day check dated 3 January 1977 indicates that a change was filed the last week in December.

Each publication requiring a 180-day check will contain an AFTO Form 2411, located behind the title page. Each of these documents requiring the 180-day check will be assigned a control number by the owning unit for use in controlling the accomplishment of currency checks and inspections. Both the 180-day check and the 7-day check of in-use technical orders are accomplished in accordance with AFM 66-1.

Exercises (087f):

1. Suppose you receive Supplement C to NI&RT 0-1-34. What must you do?

2. If, during a routine file inspection, you find that a TO in your file has been replaced by another TO which you do not have. What action should you take?

3. What should you inspect on the annual check that is not required on the routine check?

4. Where should you look to find the AFTO Form 131 to document a supplement check you have just made?

5. A 180-day check is due on work unit codes TO 1F-4C-06. What action should you take?

6. How can you find out if a 7-day check is due on any publication in your file?

7. What is the purpose of a 7-day check?

088. Differentiate between the methods used to keep technical orders current and cite the method to use when issuing a supplement.

There are several methods used to maintain technical orders current and up-to-date. TO 00-5-1, Section IV, contains specific procedures associated with changes, revision supplements, appendixes, and rescission of publications. Each method is discussed separately in the following paragraphs.

Changes. Changes are issued when only parts of the existing TOs are affected. The changed pages replace the corresponding numbered pages, and all replaced pages must be removed from the TO and discarded or placed in the replaced pages file as applicable. If a change contains additional material that cannot be fully included on a single replacement page, additional pages are issued and inserted between or after the affected pages. Pages added between pages are assigned the preceding page number plus capital letter suffixes in consecutive order. Pages added after affected pages

HEADING ARRANGEMENT

1. APPLICATION.

2. PURPOSE.

3. WHEN TO BE ACCOMPLISHED.

4. BY WHOM TO BE ACCOMPLISHED.

5. WHAT IS REQUIRED.

   a. Supply Information and Requirements.

      (1) PARTS REQUIRED PER EQUIPMENT.
      (2) ACTION REQUIRED ON ITEMS IN STOCK.
      (3) PARTS REQUIRED TO MODIFY ITEMS IN STOCK.
      (4) DISPOSITION OF REMOVED AND REPLACED PARTS.
      (5) DRAWINGS REQUIRED.
      (6) SIZE, WEIGHT, AND COST OF PARTS KIT.
      (7) DISPOSITION OF KITS.

   b. Personnel Information and Requirements.

   c. Special Tools, Fixtures, Jigs and Test Equipment Required for Operational Test of Modified Equipment.

6. HOW WORK IS ACCOMPLISHED.

7. SUPPLEMENTAL INFORMATION.

   a. Operational Checkout Requirements.

   b. Technical Orders Affected.

8. RECORDS.

   a. Action On Maintenance Records.

   b. Action on Supply Records.

   c. Reidentification of Modified Items.

AUTHORITY

Figure 5-10. TCTO Format.

continue in numerical sequence, such as 2-4, 2-5 or 21, 22, depending upon the numbering system used in the technical order.

A new title page will be issued with each change. The new title page will bear the basic TO date as well as the change number and the date of the change. When a change to a TO includes previously issued supplements, a replacement notice will be included to indicate the TO number and the date of each supplement included in the technical order. Figure 5-11 is a title page reflecting changes.

Changed pages are identified by referring to the list of effective A pages which indicates the change numbers and/or change dates. Figure 5-12 illustrates a typical A page. On the page that is changed, the change number is printed in the lower corner of the changed page with the page number. Changes in the text of a technical nature, policy, procedures, or of a similar type are indicated by a heavy black line in the outer margin opposite the changed part of the text. Corrections of minor inaccuracies of a nontechnical nature, such as spelling and punctuation, will not be marked with a black line unless the corrections change the meaning of instructive information and procedures. Figure 5-13 shows areas on the original page where the changes took place.

NOTE

When sealing for corrosion protection, provide a minimum of 0.25 inch of sealant beyond the joint.

a. Wherever possible, fillets shall be applied on the pressure side of sealed areas. Fillets may be used to fill and cover gaps as large as 0.25 inch without the use of backing plates.

b. Apply sealant (see item 12, 13, or 14, figure 1-78), evenly and continuously over all designated edges and into seams, allowing no air to be trapped under it. (See figure 1-76.)

c. Welded assemblies and parts subject to environmental moisture conditions may be fillet sealed between weld fillets to prevent corrosion.

d. When any type sealant other than Military Specification MIL-S-8802 sealant is used in a fuel bay or other area subject to contact with fuel, the sealant shall be topcoated as follows:

(1) Using brush or spray method, apply topcoating material EC776SR over tack-free sealant.

(2) Use topcoating as received, except thinning may be accomplished when material has become thick but not gelled. Use methyl isobutyl ketone for thinner.

(3) Coating shall be continuous and uniform. Allow 24 hours drying time before using the area.

e. Designated fasteners will be covered with sealant as shown in figure 1-76. No buildup of sealant shall be allowed between fasteners unless otherwise specified on a specific repair.

f. When using high temperature silicone sealants (items 22 thru 26, figure 1-78), clean and prime surfaces as specified in paragraph 1-236.

NOTE

Do not place lightweight sealant (EC5120) over MIL-S-8802 sealant nor MIL-S-8802 sealant over lightweight sealant; adhesion between the two types of sealant is poor.

1-234. Void, Hole, or Gap Sealing — Interior. Voids, holes, or gaps larger than 0.250 inch in the minimum dimension and accessible shall be covered by use of seal plates or aluminum pressure-sensitive tape where possible and overcoated with fillet type sealant, item 12, 13, or 14, figure 1-78, or high temperature sealant, items 22 thru 26, figure 1-78.

a. Seal plates shall be of 0.016 or 0.020 inch thick clad aluminum or material of like nature to the base structure. The gage and temper of the seal plates shall be determined by size of the voids, degree of forming required, location and number of rivets, fasteners, or cement needed to hold the plate in place.

NOTE

Where seal plates or other added metal parts not called out on the repair are considered necessary, an aeronautical structures engineer shall be notified and his approval obtained.

b. Seal plates may be wet sealed or fillet sealed in place.

c. Voids, holes, or gaps which are inaccessible for placement of seal plates shall be sealed as follows:

(1) For gaps or voids larger than 0.25 inch but smaller than 0.38 inch, use sealant PR1422, class B.

(2) After applying material, feather edges of sealant down to the surface of the surrounding structure.

5-13. Technical order pages—marginal indicators (changes).

Technical Order Page Supplement (TOPS) A TOPS (fig. 5-14) is different from a standard change in that a TOPS page supplements rather than replaces an individual page in a technical order. It is also different from a supplement because an individual TOPS page is filed in the TO facing the affected TO page. Technical order page supplements are stored and issued like changes but are replaced like supplements. The TOPS will be printed on green paper to distinguish them from standard changes. They are issued only when the requirement for issuing the data does not meet the criteria for safety or operational supplements, the reproducible copy or negatives for the TO are not available for use in preparing a standard page, or time and circumstances do not permit issuing a standard change.

The TO number of a TOPS is the same as the basic TO. Each TOPS is identified by a TOPS number and date printed under the basic TO date on the TOPS title page. Technical order page supplements for each TO are numbered sequentially, starting with the number 100, such as 101-13 February 1973. The number used to identify a TOPS for a TO will not be reused to identify a new TOPS for that TO for 1 year after the original TOPS has been superseded.

Revisions. A revision is a complete new edition of an existing TO and has a new basic date. It includes existing changes and replaces any supplements listed in the replacement note on the title page. Normally, a TO is revised when the pages affected by existing changes, in addition to pages requiring change, total 80 percent or more of the TO. The determination of the need for a revision is also based on factors such as the impact of changes and supplements on the usability of the TO, urgency of need for change, cost, quantity of stock on hand, and the existence of reprint incorporating (merging) existing changes. Black vertical borderline symbols indicate current changes in the text of a revision which were not previously published as TO changes or supplements.

Appendixes. An appendix is used to include material in a TO that is not part of the normal sequence outlined in the table of contents, such as tables and charts. Such added material becomes an integral part of the affected TO.

An appendix may be issued either as part of the basic TO or subsequent to the issuance of the basic TO. An appendix is issued when it is desired to include additional information in an existing TO. In this event, the appendix is issued with a change title page, and the pages of the appendix are then inserted at the end of the basic TO.

Recission. Technical orders are rescinded for Air Force use when the information is no longer required, is incorporated in other publications, or the recission date indicated in TCTOs has expired. Some TOs are rescinded for Air Force use but are retained in stock for Military Assistance Program (MAP) use. These TOs are listed in a separate Numerical Index and Requirements Table. Publications will not be removed from the files until listed as rescinded in the Numerical Index and Requirements Table.

Supplements. Supplements are issued as separate TOs to add to or to change data in the basic TO. Supplements are of two types: cumulative and noncumulative. A cumulative supplement includes all the information contained in previously issued supplements and therefore replaces them. Read the title page to see if any supplements are included in the cumulative supplement. Remove from the TO file any supplements included in the cumulative supplement. Noncumlative supplements do not contain any previously issued supplements and replace only those items listed on the title page.

Supplements have the same TO number as the TOs that they supplement except that the supplement has a letter added to the end of the TO number. The word "SUPPLEMENT" is printed in heavy black type at the top of the title page.

Safety supplements. These supplements are used as a quick way to distribute safety information correcting a TO deficiency. By this we mean that the TO, if followed as written, constitutes a hazard. The information contained in the safety supplement is incorporated in the original TO at the next revision of the TO. When this takes place, the title page of the revision or change states that the safety supplement has been included and the safety supplement is to be removed from the file.

Like other supplements, safety supplements have the same TO number as the TO they supplement. The letters "SS" are added to the TO number to identify the publication as a safety supplement. The last number in the safety supplement number indicates the number of that supplement. For example: the first safety supplement to TO 1F-106A-1 would be TO 1F-106A-1-SS-1; the second safety supplement would be TO 1F-106A-1-SS-2; and the third would be TO 1F-106A-1-SS-3.

Operational supplements. These supplements are issued as a quick way to reflect information when work stoppages or operational defects related to the accomplishment of the mission are involved. The information contained in operational supplements is incorporated in the original TO when the original TO is revised or changed. Operational supplements are numbered the same way that safety supplements are numbered except that the operational supplement uses a single letter "S" rather than the double "SS". The reason for not using "OS" is that the "O" might be read as a zero instead of the letter.

Methods of Issuing Supplements. Safety and operational supplements are issued two ways: interim and formal. Interim supplements are issued by electrical transmission to the headquarters of the using commands. The headquarters passes the information on to all affected activities of the command. Interim safety supplements are issued when safety conditions exist which result in fatal or serious injury to personnel, or when extensive damage or destruction of property or equipment is involved. Interim operational supplements are issued to correct conditions when the using

ANSWERS FOR EXERCISES

CHAPTER 1

Reference:

001 - 1. 1. e.
2. d.
3. b.
4. a.
5. c.

002 - 1. 427.
002 - 2. Indicates individual specialty in which you work.
002 - 3. The fourth.

003 - 1. 42715.
003 - 2. 1. 42715—Airframe Repair Helper.
2. 42735—Apprentice Airframe Repair Specialist.
3. 42755—Airframe Repair Specialist.
4. 42775—Airframe Repair Technician.
5. 42799—Fabrication Superintendent.

004 - 1. Job descriptions for all airmen AFS at the different skill levels.
004 - 2. The STS sets the level of training you will receive at each skill level.
004 - 3. For planning purposes.
004 - 4. Used to identify the proficiency required at each skill level.

005 - 1. Drill, rivet, cut, form, and bond metal in the fabrication and repair of metal and nonmetal parts and components.
005 - 2. With supervision.
005 - 3. By assisting a skilled specialist.

006 - 1. Performance.
006 - 2. Repair, modify, and fabricate aircraft metal, plastic, fiberglass, and honeycomb structural parts.
006 - 3. The experience will be helpful as a technician.
006 - 4. Team leader of repair crews and conducting phases of on-the-job training.

007 - 1. 42775.
007 - 2. Shop or shift supervisor.
007 - 3. a. no, b. yes, c. no, d. yes, e. no.

008 - 1. 42799.
008 - 2. Master Sergeant.
008 - 3. Supervision.
008 - 4. B and d are circled.

009 - 1. Classified.
009 - 2. Unclassified.
009 - 3. Unclassified.
009 - 4. Of possible intelligence value.

010 - 1. Top Secret.
010 - 2. For Official Use Only.
010 - 3. Confidential.

010a - 1. To keep the advantage of surprise on our side.
010a - 2. By quality workmanship and not becoming a security leak.
010a - 3. Because of the nature of your job.
010a - 4. "Don't carry tales home from work"—what goes on in the shop and flight line should be told only to those who have a *need to know*.

011 - 1. Only authorized personnel who have a need for the material.
011 - 2. The locations where the prescribed facilities are available for its secure storage or protection.
011 - 3. Attendance at a conference, overhearing a conversation, or being exposed to classified material in the performance of your regularly assigned duties.
011 - 4. Money, drugs, and other valuables.
011 - 5. Security category and type of material.

012 - 1. c. and d.
012 - 2. d.
012 - 3. a.
012 - 4. b. and c.

013 - 1. The right and need to know.
013 - 2. Not unless he can clearly establish his need to know.
013 - 3. No.

CHAPTER 2

014 - 1. Leadership qualities.
014 - 2. Sincere, friendly, and patience.
014 - 3. Creates a willing, cooperative, progressive, and continuously improving work force.
014 - 4. Rate the individual on actual performance rather than upon his friendly overtures to you.
014 - 5. Each worker is an individual.

015 - 1. So that the worker will be happy and satisfied with his job.
015 - 2. Give any three of the following:
1. Give a man a pat on the back and a little praise when he does a good job.
2. Use letters of appreciation and commendations.
3. Recommend outstanding performance ratings.
4. Recommend personnel for promotion, upgrading, and better assignments.
5. Encourage use of suggestion programs.
015 - 3. Supervisor's attitude and conduct.
015 - 4. By being friendly, helpful, and fair in his dealing with the worker.

016 - 1. Mission completion and personnel safety.
016 - 2. Safety.
016 - 3. Request.

016 - 4. (1) Control work in another location.
(2) Give orders involving precise specifications or complicated details.
(3) Hold a worker strictly accountable.
(4) Control work in which the order of performance is important.

016 - 5. (1) Explain minor details.
(2) Give assistance.
(3) Clarify a written order.
(4) Give instruction in an emergency.
(5) Stimulate worker interest.

017 - 1. c.
017 - 2. a.
017 - 3. b.
017 - 4. d.
017 - 5. f.
017 - 6. e.

018 - 1. Coordinate with your supervisor about the higher priority work request; then coordinate with the other shop supervisor and your specialist about completing the higher priority work. Be prepared to delay the lower priority work.
018 - 2. To keep everything in balance within the shop and with outside activities. This is necessary for mission completion.

019 - 1. Size of workload, number of people, each one's skill level, and the equipment available.
019 - 2. Mission.
019 - 3. Repair of the aircraft part.

020 - 1. Flying requirements.
Scheduled maintenance.
Inspection results.
020 - 2. For improvement within his area.
020 - 3. In-shop records.

021 - 1. True.
021 - 2. False.
021 - 3. True.
021 - 4. False.
021 - 5. False.

022 - 1. Unity of command.
022 - 2. Logical assignment.
022 - 3. Delegation of authority.

023 - 1. Usually four, the level being charted, the one above, and the two below.
023 - 2. Blocks 4c should be on the same level and size as blocks 4a and 4b.

024 - 1. Skill level and experience, job priority, and work distribution.
024 - 2. Assign it to Ed to round out his experience and knowledge.

025 - 1. What constitutes a satisfactory job.
025 - 2. To tell him what is expected of him in completing his job.
025 - 3. Operating details are overemphasized.
025 - 4. Realistic; practical.
025 - 5. A certain range of performance is considered acceptable.
025 - 6. 1. Quantity of results in a given time.
2. Quantity of results in how well a job must be performed.
3. Manner of performance.
026 - 1. 1. How does the worker meet the performance standards?
2. What are his working conditions?
3. What is my attitude toward him?
026 - 2. Give any five of the following:
1. Improve production.
2. Improve worker attitude.
3. Provide a basis for estimating future work capacity.
4. Provide a basis for planning, organizing, and assigning work.
5. Provide a basis for planning training.
6. Provide a basis for formal evaluation.
7. Provide a basis for personnel actions.
026 - 3 1. Did I supervise properly?
2. Are my personal feelings affecting my evaluation?

027 - 1. 1. To improve methods, by making them safer, cheaper, and faster.
027 - 2. (1) Suggestion Program and (2) Chain of Command.
027 - 3. An adopted change that saves money.

028 - 1. Training needs is the difference between what a trainee can do and what he must do.
028 - 2. Valuable time and money would be wasted.
028 - 3. By checking the specialty description, the STS, and performance requirements.
028 - 4. Background, training, and experience.

029 - 1. OJT is the concern of everyone assigned to the unit.
029 - 2. AFR 50-23 is used for planning, administering, supervising and conducting OJT programs.
029 - 3. The career development channel provides the knowledge portion of the training, while the job proficiency channel provides the actual performance of the job.
029 - 4. The STS is used to assign required training and record completed training.

030 - 1. c.
030 - 2. a.
030 - 3. a.
030 - 4. b.
030 - 5. d.
030 - 6. c.
030 - 7. b.
030 - 8. d.
031 - 1. e.
031 - 2. a.
031 - 3. c.
031 - 4. a.
031 - 5. d.
031 - 6. e.
031 - 7. b.
031 - 8. f.
031 - 9. e.
031 - 10. c.
031 - 11. d.
031 - 12. a.
031 - 13. f.
031 - 14. e.
031 - 15. b.
032 - 1. AF Form 623a.
032 - 2. Section IV.
032 - 3. Section I.
032 - 4. Section II.
032 - 5. Section V.
032 - 6. Section III.
032 - 7. Section I.
032 - 8. Section IV.

033 - 1. To evaluate present training.
033 - 2. STS.
033 - 3. When the graduate does not meet the proficiency level; when the graduate is not required to perform tasks listed in the STS; and when STS code levels or tasks exceed the requirement of the graduate's AFSC.
033 - 4. CDCs are designed to provide the learning materials. OJT utilizes these knowledges to train the trainee.
033 - 5. By having discussions with the graduate, his immediate supervisor, and others having knowledge of the graduate's performance.
033 - 6. Questions pertain to the graduate's qualification in terms of skills and proficiency levels reflected in the approved training standard.
033 - 7. To identify, if any, weak areas in the CDC.

CHAPTER 3

034 - 1. To insure that the necessary supplies and equipment are available for the AF to meet its mission requirement.
034 - 2. Needed; justified.
034 - 3. AFM 67-1, *USAF Supply Manual*.
034 - 4. The cost of an item.
034 - 5. Priority.

035 - 1. 4730—Federal Supply Classification Code (Group and Class).
00-194-1089—National item identification Number. The first two digits, 00, represent the country assigning the stock number, and the remaining digits distinguish a specific item of supply.
035 - 2. To segregate items for management purposes, identify according to their application, and indicate items associated with special programs.
035 - 3. All participants using the Federal Cataloging System must agree.

036 - 1. 5340.
036 - 2. Water turbines and water wheels; and components.
036 - 3. C-RL-2.
036 - 4. C-RL-2.
036 - 5. C-RL-1.

037 - 1. To locate the specific group class numbers.
037 - 2. To complete the remaining portion of the stock number.
037 - 3. To find the item description.
037 - 4. To cross-reference the part number to a stock number.
037 - 5. To find the unit of issue, source category, and cost.

038 - 1. 1. d., 2. e., 3. c., 4. a., 5. b.
038 - 2. a. 4151, b. J, c. 0050, d. EB, e. 629.

039 - 1. 1. The telephone extension was not given.
2. Unit of issue should be EA, HD DZ BX, etc., not 01.
3. Quantity should be preceded by slashed zeros (ø).
4. Nomenclature is entered in wrong block.
5. Destination is not given.

040 - 1. When you need to order a part that doesn't have a stock number.
040 - 2. 4266.
040 - 3. 122cw.
040 - 4. This is necessary to insure that the correct item is purchased.
040 - 5. In case questions arise concerning the purchase of the part or a possible substitute.

041 - 1. When checking out an item for a short period of time.
041 - 2. When ordering parts and signing for parts received.
041 - 3. Block 13, Julian date and time; block 14, signature; and block 15, printed name and rank.
041 - 4. They provide supply with records of issues and hold the receiver of the items accountable.

042 - 1. Becuase it can be used both for issue and turn-in of supplies.
042 - 2. Request for replacement of condemned items.
042 - 3. From the table of allowances.

043 - 1. Unserviceable (Reparable) Tag—Materiel, DD Form 1577-2.
043 - 2. Serviceable Tag—Materiel, DD Form 1574.
043 - 3. Items whose repair costs exceed 75 percent of the item's original cost are condemned. A DD Form 1577 tag is used.
043 - 4. Serviceable DD Form 1574.

044 - 1. Allows uninterrupted repairs and speeds up the return of repair parts to their users.
044 - 2. Supply personnel.
044 - 3. The shop.
044 - 4. Order the item from Demand Processing using normal issue procedures.

045 - 1. Consolidate index of all USAF equipment allowance documents.
045 - 2. To find out what tools are authorized in a toolkit.
045 - 3. To check the types and amount of equipment authorized in a sheet metal and plastic shop.
045 - 4. Coordinate with Material Control to substantiate the need for this equipment, then acquire the equipment.

046 - 1. You are responsible.
046 - 2. SSgt Jones is accountable.
046 - 3. All personnel who use the equipment are responsible for its care.

047 - 1. The property you use in the completion of your work is your responsibility, even if its accountability lies with someone else.
047 - 2. Supervisory responsibility applies to any person who exercised supervision over property received, in use, in transit, in storage, or undergoing modification or repair.
047 - 3. A DD Form 362 is used when a person admits pecuniary liability for an item but doesn't have the cash to pay for it.
047 - 4. A DD Form 1131 is used when a person admits pecuniary liability for an item and desires to pay cash.

048 - 1. DD Form 200.
048 - 2. Immediately after it is known that the loss, damage, or destruction of property has occurred and no one will admit liability.
048 - 3. The liable person must reimburse the Air Force.
048 - 4. He uses DD Form 1131, Cash Collection Voucher, or DD Form 362, Statement of Charges.

CHAPTER 4

049 - 1. Highly qualified in leadership, management, and administration.
049 - 2. He manages, plans, controls, executes, and produces the work needed to fulfill the mission of the maintenance organization.
049 - 3. Direction and guidance.

050 - 1. Job Control, Plans and Scheduling and Documentation, and Materiel Control.
050 - 2. a. Materiel Control.
b. Plans and Scheduling and Documentation.
c. Job Control.
d. Plans and Scheduling and Documentation.
e. Materiel Control.
f. Job Control.
g. Plans and Scheduling and Documentation.
h. Materiel Control.
i. Plans and Scheduling and Documentation.
j. Materiel Control.

051 - 1. Deficiency analysis, inspection, standardization-evaluation, weight and balance, technical order library, functional check flight and deficiency reporting.
051 - 2. a. Deficiency analysis.
b. Inspection.
c. Deficiency reporting.
d. Standardization-evaluation.
e. Deficiency analysis.
f. Functional check flight.
g. Technical order library.
h. Weight and balance.

052 - 1. 1. c.
2. b.
3. a.

4. c.
5. a.
6. b.
7. b.
8. c.
9. a.
10. b.

052 - 2. a. Programs and Mobility.
b. Production Analysis.
c. Administration.
d. Production Analysis.
e. Administration.

053 - 1. a. AMS.
b. FMS.
c. OMS.
d. FMS.
e. MMS.
f. FMS.
g. OMS.
h. AMS.
i. OMS.
j. FMS.

053 - 2. 1. c.
2. b.
3. a.
4. b.
5. c.
6. b.
7. d.
8. b.
9. a.
10. c.

053a - 1. The maintenance activities are reorganized by major tasks to support each flying squadron under the POMO maintenance concept.

053a - 2. The categories are determined by whether the maintenance performed is accomplished *on* or *off* the equipment (aircraft).

053a - 3. The AGS is primarily concerned with on-equipment maintenance. The CRS is primarily concerned with off-equipment maintenance, while the EMS is responsible for the off-equipment maintenance of powered AGE and selected aircraft components and extensive on-equipment of aircraft and AGE.

053a - 4. The objective is to foster rapport between aircrew members and maintenance people and to encourage more maintenance identification with flying mission.

053a - 5. The squadron is functionally divided into these branches: Propulsion Avionics, Accessory Maintenance, and the Precision Measurement Equipment Laboratory.

053b - 1. The type of maintenance will be mostly on-equipment (minor repairs) accomplished on the flightline.

053b - 2. The type of maintenance will be mostly off-equipment repair within a structural repair shop.

053b - 3. The maintenance squadron of assignment.

053b - 4. When assigned to AGS, you will, along with normal upgrade (skill level) training, receive assist task qualification training and specific cross-utilization training (CUT).

053b - 5. When assigned to CRS, you will receive the normal upgrade (skill level) training.

054 - 1. 1. Organizational.
2. Intermediate.
3. Organizational, Intermediate, and Depot.
4. Depot.
5. Intermediate.

055 - 1. 1. Preflight inspections are performed before the first flight of the day, when an aircraft goes into and out of alert status, and when an airline type of aircraft remains on the ground until the next calendar day.
2. To determine if the aircraft is suitable for another flight.
3. After a specified number of flying hours have accumulated.
4. When the specified number of flying hours or calendar period has expired.
5. When cargo aircraft is utilized for regular airline type operations.

056 - 1. Combination of the basic postflight and/or hourly postflight and periodic inspection requirement into small packages.

056 - 2. To reduce the "out of commission" time of the aircraft.

056 - 3. The amount of flying time accrued.

057 - 1. Home station check.

057 - 2. Minor and major inspections.

057 - 3. A basic postflight or home station check is required.

057 - 4. A hourly postflight inspection or home station check, plus performance of an operational check of all functional aircraft systems.

058 - 1. Inspections accomplished at the aircraft on the flightline are called the inplace method.

058 - 2. The "dock" method is accomplished at a specially prepared site, such as a large maintenance hangar.

059 - 1. To indicate the condition of the aircraft.

059 - 2. a. Red diagonal.
b. Circled red X.
c. Red X.
d. Red dash.
e. Black last name initial.
f. The letter C inside a red circle.

060 - 1. Left-hand column entries:
a. SYM.—Red X.
b. Date Discd.—01/07/5.
c. WDC—F.
d. JCN—1830066.
e. Discrepancy—Loose rivets in the intake of No. 2 engine.
f. Discovered By—H. Jones, A1C.

Right-hand column entries.
a. Corrective Action—Replaced loose rivets in No 2 engine intake.
b. Date Corrected—01/07/5.
c. Corrected By—A. Smith, Sgt.
d. Inspected By—H. Madison, MSgt (who entered his first initial of his last name in the SYM block, in the left-hand column).

061 - 1. Determine problem areas and manpower and spare parts requirements.

061 - 2. Accurate recording of data on the maintenance forms.

061 - 3. "On-equipment" documentation.

061 - 4. "Off-equipment" documentation.

061 - 5. Productive indirect.

062 - 1. The individual performing the maintenance records the maintenance accomplished on the AFTO Form 349.

062 - 2. Maintenance Data Collection System.

062 - 3. Record maintenance actions and serve as a dispatch notice.

062 - 4. Any part defective or thought to be defective.

062 - 5. Part 1, processing document.
Part 2, schedule control document.

063 - 1. Job Control Number—016-0003.

064 - 1. The workcenter code to be recorded in block 2 of figure 1, foldout 1, is A3130.

065 - 1. So that an accurate account of maintenance performed on a specific piece of equipment is maintained.

065 - 2. a. A.
b. B.
c. 6153.
065 - 3. Enter AA3407 in block 3.

066 - 1. To identify a specific item being repaired.
066 - 2. No, because an I.D. No./Serial No. is shown.

067 - 1. Job Control.
067 - 2. a. 1.
b. 3.
c. 2.
d. 2.
e. 1.
067 - 3. Priority 2.

068 - 1. When the AFTO Form 349 is used as a dispatch form.
068 - 2. Type maintenance that you'll be performing, other maintenance being performed at the same time, and the length of time it will take you to complete your job.
068 - 3. The average time it takes to accomplish a certain job.
068 - 4. 0930—show time; 3.0 standard.

069 - 1. The description in block 26 must agree with the entries made in blocks C and F.
069 - 2. A brief and accurate description of the discrepancy.

070 - 1. No. A brief, but accurate account of the maintenance performed must be entered.
070 - 2. Action Taken, column D.
070 - 3. For additional space needed for blocks 26 and 27.

071 - 1. Indicates the type of work that was accomplished.
071 - 2. B, (Unscheduled).
071 - 3. Discrepancy is not on an engine.
071 - 4. 1311U.

072 - 1. Action Taken—G, When Disc—F, and How Malfunctioned Code—190.
072 - 2. When an item is bent, buckled, collapsed, dented, distorted, or twisted.
072 - 3. Used only when another "on-equipment" code will not fit the maintenance situation.
072 - 4. M.

073 - 1. 0.
073 - 2. Eight AFTO Forms 349 are completed; only one has 1 unit of work produced recorded.
073 - 3. (1) one.

074 - 1. Start Time—0935.
074 - 2. Columns:

G	*H*	*I*
0	0935	0161130
1	1230	0161330

074 - 3. Columns:

J	*K*
1	1
1	3

074 - 4. Two action line entries.

075 - 1. The 2-position command code of the owning command of transient aircraft or equipment with no I.D. number assigned.
075 - 2. To indicate maintenance accomplished on items based on the date of previous maintenance.
075 - 3. Columns:

L	*M*	*N*
Blank	Blank	J8934
Blank	Blank	S6136

076 - 1. Identifies status of the reparable item, provides a source document for information, and provides a means for controlling the flow of items to and from the maintenance shops.
076 - 2. Blocks 1 through 14.
076 - 3. Block 1—0160003.
Block 2—AA3407.
Block 3—B.
Block 4—F.
Block 5—190.
Block 6—C-130A.
Block 7—1311U.
Block 9—1.
Block 10—1560.
Block 11—35678-1A.
Block 14—"Bracket Assy. on the main landing gear retracting mechanism cracked."

077 - 1. AFTO Form 350.
077 - 2. Block 1—0160003.
Block 2—A3130.
Block 3—AA3407.
Block 7—2.
Block 19—1560.
Block 20—35678-1A.
Column A—B.
Column C—1311U.
Column D—A.
Column E—F.
Column F—190.
Column G—1.
Column H—1430.
Column I—016/1630.
Column J—1.
Column K—1.
Column N—J1374.
Block 26—"Bracket Assy. on the main landing gear retracting mechanism cracked."
Block 27—"Bench checked and repaired."
077 - 3. Block 15—"Installed patch on bracket assy.
Block 26—16 Jan 75, John Johnson.

078 - 1. Block 1—015-0030.
Block 2—A3130.
Block 3—AINDLB.
Column C—DTLOO.
CMPOO.
Column H—1300.
1230.
Column I—015/1500.
015/1630.
Column J—3.
1.
Column K—1.
2.

079 - 1. To establish methods that feed back deficiency data to activities responsible for an item so that corrective and preventive actions can be taken.
079 - 2. a. I; b. II; c. II; d. II; e. I; f. I; g. II; h. I; i. I; j. I.
079 - 3. Electrically on a DD Form 173, Joint Messageform.
079 - 4. By AUTODIN using SF Form 368 format.

080 - 1. They can be used to improve work methods and evaluate current working practices.
080 - 2. AFTO Form 95, Significant Historical Record.
080 - 3. Maintenance data collection reports.

CHAPTER 5

081 - 1. To insure the performance of the AF mission with the greatest possibility of success and the least chance of loss of life or damage to equipment.
081 - 2. AFR 8-2, *Air Force Technical Order (TO) System.*
081 - 3. Contains information, instructions, and safety procedures pertaining to the inspection, operation, maintenance, and modification of Air Force equipment and material.
081 - 4. TO 00-5-2, *Technical Order Distribution Systems.*
081 - 5. To become familiar with the TO system and use tech data in accomplishing maintenance.

082 - 1. d.
082 - 2. c.
082 - 3. a.
082 - 4. b.
082 - 5. c.
082 - 6. d.
082 - 7. e.
082 - 8. a.
082 - 9. b.
082 - 10. d.

083 - 1. To distinguish one technical order from another and provide a systematic grouping of technical publications.
083 - 2. The category of technical order.
083 - 3. The actual information that the technical order contains.
083 - 4. 1F-109B-3.
083 - 5. a. 1.
b. 34.
c. 2.
d. 3.
e. B.
f. 4.

084 - 1. 1 June 74.
084 - 2. Maintenance Documentation for In-Shop Eng Maint, OC.
084 - 3. Fighter Aircraft Technical Orders.
084 - 4. 30 Aug 75.

085 - 1. The category of technical order for a piece of equipment when you only know the name of the item.
085 - 2. By adding "0-1-" in front of the category found in the alphabetical index.
085 - 3. By gathering all the information you can about the equipment.
085 - 4. a. Locate the TO category in alphabetical index.
b. Add "0-1-" in front of category, developing specific NI&RT.
c. Turn to the table of contents for the specific NI&RT.
d. Locate specific piece of equipment in table of contents.
e. Turn to the pages indicated in NI&RT containing a listing of TOs for the piece of equipment.

086 - 1. Urgency of the information.
086 - 2. By an electrically transmitted message and is usually issued for immediate action and urgent action TCTOs.
086 - 3. a. Immediate Action TCTOs—Red X.
b. Urgent Action TCTOs—circled red Xs.
c. Routine Action TCTOs—none.
d. Interim TCTO—none.
086 - 4. A category 1 TCTO specifies that work be accomplished by field or organizational maintenance.
A category 2 TCTO specifies that work be accomplished by the depot during depot-level maintenance.
086 - 5. When the maintenance action required by the TCTO is not accomplished within the specific time periods.

087 - 1. Deputy Commander for Maintenance.
087 - 2. Because of the urgency of the information.
087 - 3. Mission priority.
087 - 4. They are colored green.
087 - 5. Immediately turn the kit back into the TCTO control section.

087a - 1. TO 00-5-2.
087a - 2. In a place that provides convenient immediate reference for using personnel.
087a - 3. Whether they are required to accomplish the operational and maintenance responsibilities of the activity they serve.
087a - 4. In the same sequence that they are listed in the NI&RTs.
087a - 5. Book sequence number, number of the first TO in the binder, and the number of the last TO in the binder.
087a - 6. File the title page in the TO file and make a notation on it to indicate the location of the manual.

087b - 1. a., ID; b., Req; c., Req; d., ID.
087b - 2. a., 3; b., 1; c., 4; d., 5; e., 7; f., 6; g., 2.

087c - 3. *Note: You* should have entered your account number and the current date in the spaces provides in the Data Message Form Information portion of the AFTO Form 187.

	TO Number	*ID Qty*	*One Time Req Qty*
087c - 1.	1-1A-8		0001
087c - 2.	1F-15E-3	0002	0001
087c - 3.	1F-4C-3-1	XXXX	
087c - 4.	1C-135(K)-3-1	0001	0000

087d - 1. Part III, of the AFTO Form 187:

TO Number	*Qty*	*Original Req Date*
1-1A-8	0001	18 Jan 78
Fol-Up Data		*Orig Req No*
A		00033

087d - 2. Part II of AFTO Form 187:

TO Number	*Qty*	*Original Req Date*
1F-4C-4	0001	30 Dec 77
Fol-Up Data		*Orig Req No*
		00584

087e - 1. The following answers are the actions occurring for each transaction in time sequence:

Part I:

Block 1 - TO 1F-4C-3-1.
Block 2 - No entry required because TO is unclassified.
Block 3 - 3.
Line item B - the number 3 should be entered under account #19 (line item A).
Line item C - The number "0" should be entered under the number 3 (line item B) entered under account #19 (line item A).
Line item A - (total block) - 3.

Part II

Block 1 - 00030.
Block 2 - 13 Jan 77.
Block 3 - 3.

087e - 2.

Part I:

Block 1 - TO 1F-4C-3-1 (first line).
Block 1 - 15 April 1974.
Block 3 - Blank.
Block 4 - 3.
Block 5 - 11 Feb 77.

087e - 3.

Part I:

Line item C is changed to 2.
Line item d, a minus sign is entered under the 2 just enter in line item C.

Part III

Block 1 - CHG #1 (line 2).
Block 2 - 15 June 1977 (line 2).
Block 3 - Blank (line 2).
Block 4 - 2 (line 2).
Block 5 - 26 June 1977 (line 2).

Block 6 - *19* (line 2) 1.
Block 7 - 1 (line 2).

Part IV

Block 1 - CHG #1.
Block 2 - 26 June 1977.
Block 3 - 00037.
Block 4 - 1.
Block 5 - *19* 1.

087e - 4.

Part I:

Line item C is changed to 3 from 2.
Line item d has the minus sign removed.

Part III

Block 1 - S-7 (line 3).
Block 2 - 22 July 1977 (line 3).
Block 3 - Blank (line 3).
Block 4 - 3 (line 3).
Block 5 - 8 August 1977 (line 3).
Block 8 (line 2) - 8 August 1977.

Part IV

Block 6 (line 1) - 8 August 1977.
Block 7 (line 1) - 1.

087e - 5.

Part III:

Blocks 1, 2, and 3 on line 3 are lined out.
Block 1 (line 4) - CHG #2.
Block 2 (line 4) - 1 November 1977.
Block 3 (line 4) - Blank.
Block 4 (line 4) - 3.
Block 5 (line 4) - 17 December 1977.

087f - 1. Within 10 days following receipt of the supplement, you must check all your AFTO Forms 110 for TOs listed in the supplement against the supplement for currecy. Also, document the supplement check on the AFTO Form 131 for NI&RT 0-1-34.

087f - 2. Request the current TO and Part I of the AFTO Form 110, enter a "minus" in line D, and write "REPLACED" above block 1.

087f - 3. The contents of the TO file are inspected for deficiencies or excesses which may have been overlooked in the routine checks. Only the 110 file is inspected on the routine check.

087f - 4. In a binder labeled "Supplement and Annual NI&RT Inspection File."

087f - 5. Check the publication against the current NI&RT for currency and check the contents of the publication against the list of effective pages for completeness and currency. Also, document the inspection on the AFTO Form 2411 on the inside of the cover page.

087f - 6. Check the weekly maintenance plan to see if Quality Control has listed new changes or revisions for any of your workcards, checklists, or work unit code manuals.

087f - 7. To verify that the latest change or revision was properly filed.

088 - 1.
1. b.
2. a.
3. d.
4. e.
5. c.
6. f.
7. g.
8. h.
9. b.
10. d.

088 - 2. Interim.

088 - 3. Formal.

089 - 1. The activity responsible for the corrective actions must respond within 48 hours either by issuing a TCTO or by disapproving or downgrading the report.

089 - 2. To recommend the correction of nonemergency TO deficiencies.

089 - 3. The person discovering the error in the TO.

089 - 4. The responsible activity must answer within 30 calendar days or within 20 days if the action cannot be completed within 30 days or if the report is disapproved or downgraded.

089 - 5. These reports are used to recommend improvements to TOs to correct potential hazards.

CHAPTER 6

090 - 1. The identification and elimination of accident causes.

090 - 2. Safety engineering involves controlling the work situation to minimize physical hazards.

090 - 3. Some people are a hazard to themselves and others because of their failure to comply with accepted safety standards.

090 - 4. Through adequate education and instruction.

090 - 5. Unsafe acts and conditions.

090 - 6. Unsafe personal characteristics of an individual.

090 - 7. The heredity and early environment of an individual.

091 - 1. AFR 127-101 provides practical accident prevention information and guidance to all Air Force personnel.

091 - 2. Smoking is not allowed within 50 feet of a hangar, fuel tank, parked aircraft, or area where flammable materials are stored.

091 - 3. To prevent electrical shocks or burns, and to remove the possibility of losing a finger if the ring should snag on something.

091 - 4. Loose clothing could get caught in moving machinery, and clothing that has been splashed with oil or solvent could ignite.

091 - 5. It is dangerous to personnel and can result in extensive damage to aircraft and equipment.

092 - 1. Keep floors clean and free of oil, grease, water, or other hazardous and slippery materials.

092 - 2. Oily rags should be disposed of in metal containers equipped with self-closing lids.

092 - 3. Cut the scrap metal small enough so as not to protrude out of the container.

092 - 4. Never cut small pieces of metal from the metal in storage.

092 - 5.
a. Storage area should be in cool and dry place.
b. Provide ventilation to prevent fume buildup.
c. Identify acid and alkaline properly and store them separately.

093 - 1. Carelessness, poor housekeeping, poor storage practices, overloaded electrical outlets, and misuse of smoking materials.

093 - 2. Class A—wood, paper, textiles; Class B—oil, greases, paints; Class C—live electrical equipment.

093 - 3.
1. B and C.
2. A.
3. B and C.
4. A.
5. A.
6. B and C.
7. A and B.

093 - 4. 3; 6.

094 - 1. Color coding of machinery parts, the grounding of electrical equipment, the guarding of moving machinery, and safety inspections.

094 - 2. Movable.

094 - 3. When the machine is off.

094 - 4. Have it checked out.

094 - 5. Know how to operate your equipment.

095 - 1. Use the right type hammers for a given job.
095 - 2. People don't know how to use them properly.
095 - 3. a. Always use a file handle.
b. Clamp the item being filed into a vise.
c. Don't use file for prying.
095 - 4. Goggles and rubber guard.
095 - 5. When they are of the explosion-proof design.
095 - 6. a. Don't point the tool at anyone.
b. Don't change rivet sets without first turning off the air.
c. Don't use compressed air to remove dirt or dust.

096 - 1. When there is the probability of flying objects.
096 - 2. Gloves and safety toe shoes.
096 - 3. Respirator.
096 - 4. Because of the high noise level.
096 - 5. Safety toe shoes.

097 - 1. Stop and wait for a green light.
097 - 2. You must clear the area of personnel and equipment.
097 - 3. Insert your ear plugs.
097 - 4. Insert your ear plugs.
097 - 5. Leave the area until the radar operation is completed.

098 - 1. a. Work platform is free of oil, grease, etc.
b. All locks work.
c. Guard rails are in place.
098 - 2. Stay out if you have no business in the cockpit.
098 - 3. Install safety locks to prevent movement, and place a placard (sign) at the controls indicating maintenance is being accomplished and not to use the controls.
098 - 4. Ask someone who knows and have him check for you and at the same time show you the location.
098 - 5. To prevent damage to areas not constructed to be stepped on.

099 - 1. To reduce the amount of damage caused by foreign objects.
099 - 2. a. Stone—natural and unnatural.
b. Metal.
c. Miscellaneous.
099 - 3. a. Walkdown.
b. Proper clothing.
c. Tool inventory.
d. Repair parts inventory.
e. Removal of personal items from clothing.

099 - 4. Every maintenance man.
099 - 5. Stones.
099 - 6. Removal of personal items from clothing.

100 - 1. Mishaps on ground or water involving Air Force personnel or property, on or off an Air Force installation.
100 - 2. Total disability (even if temporary) and/or property damage.
100 - 3. When one or more fatalities five or more disabling injuries, or $10,000 or more in property damage occurs.
100 - 4. So that the Air Force can take corrective action and do what is necessary to prevent recurrence.
100 - 5. The installation ground safety office, acting for the investigating commander.
100 - 6. Within 8 hours.
100 - 7. Aid the injured, evacuate the area if additional injury is likely, and notify your supervisor as soon as practical.
100 - 8. As a nondisabling injury and in accordance with command directives.
100 - 9. As a major ground accident. A message is transmitted to concerned activities within 8 hours and is followed by a formal report within 30 calendar days.

CHANGES FOR THE TEXT: VOLUME 2

Pen-and-Ink Changes:

Page-Col	*Subject*	*Line(s)*	*Correction*
Cover		4	Change "AFSC 53153" to "AFSC 42755."
27L		22	Change "althoug" to "although."
33R		9	Change "detaild" to "detailed."
86L		13	Change "0.051" to "0.050."
101L		17–20 fr bot	Change to read as follows: "*a.* deca = 10 or ten times. *b.* hecto = 100 or one hundred times. *c.* kilo = 1,000 or one thousand times. *d.* mega = 1,000,000 or one million times."
111R		last	Change "numer" to "number."
112R		2	Change "esential" to "essential."
149R		17–26 fr bot	Delete entire paragraph.
155R		3 fr bot	Add this sentence to the end of the paragraph: "The last pass should be made with the machine set in the high-speed position."
159L		9 fr bot	Change "th" to "the."
171L		8 fr bot	Add "(air-operated type)." after the word "stringer."
171R		4	Insert "guide" between "inch" and "drill" and place a period after the first "recommended." Delete the remainder of the sentence.

53153 03 7701

CDC 53153

AIRFRAME REPAIR SPECIALIST

(AFSC 53153)

Volume 3

Repair Procedures

Extension Course Institute

Air University

433

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Preface

THIS VOLUME is designed to describe to you the general repair techniques and procedures used in making repairs to damaged metal structures. Since, just about every repair that you will accomplish involves drilling and riveting, the first chapter takes an in-depth look at the tools, equipment, and techniques used in drilling and riveting. The next three, Chapters 2 through 4, are sequenced in the steps that you will follow in making a repair—research, damaged removal and fastener layout, and lastly, the fabrication and installation of repair parts. The final chapter introduces special repair situations that will require additional skills on your part. Spotweld repairs, metal fuel tanks repairs, and the repair and application of structural sealants are the special repair situations discussed.

Remember, specific procedures for accomplishing aircraft structural repairs and maintenance of tools and equipment must be in accordance with applicable maintenance manuals.

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Material in this volume is technically accurate, adequate, and current as of August 1976.

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NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Drilling and Riveting

FOR YEARS YOU have been fastening things together. You fasten the left side of your shirt to the right side with a device known as a button. You really don't "button up the aircraft," but as you know, certain fastening devices are used to hold access panels, fairing, skin panels, cowling, patches, etc., onto the aircraft.

In the first section of this chapter, equipment and tools, along with the required procedures necessary for preparing metal surfaces to receive fasteners, will be covered. The skills you develop in drilling and countersinking have a direct bearing on the quality of your work. For this reason, it is to your advantage to practice the procedures outlined in the first part of this chapter.

The second section of this chapter deals with the most often used fastener in aircraft construction—the solid rivet. You must be able to identify head shapes, alloy composition and select the correct type of rivet for a given job.

1-1. Drilling Procedures

Nearly all fabrication and installation of sheet metal components involve the drilling of holes. You must, therefore, be familiar with the tools and equipment used and the operations involved. It is important for you to use the correct terms when speaking about drilling equipment. For example, the word "drill," when used loosely, may cause some confusion in communication. Thus, a twist drill is the part that cuts the hole; whereas a hand drill, a portable drill (air or electric), or a drill press will supply the rotary motion and torque to rotate the twist drill.

400. Cite work situations requiring the use of each type of drilling equipment and identify a safety device used when any drilling equipment is operated.

Various work situations will dictate which type of drilling equipment you use. The three basic types of equipment you can use to drill holes are these: (1) the hand drill, (2) the portable pneumatic drill, and (3) the drill press.

Hand Drills. Hand drills are used to drill holes in light gage sheet stock. The chuck will normally accommodate a twist drill up to 1/4-inch diameter. Hand drills are often used on jobs where only one or two holes are to be drilled, since the holes can be drilled in less time than it would take to set up a power unit for a pneumatic (air) drill. There will be occasions in your airframe work when power is not available and the work areas cannot be reached with an airhose. Figure 1-1 illustrates a typical hand drill used by an airframe repairman.

Portable Pneumatic Drills. You will find that a small portable pneumatic drill is usually the most practical machine to use in airframe work. Portable drills are manufactured in several sizes, which include 1/4, 3/8, and 1/2 inch, as illustrated in figure 1-2. The 1/4-inch drill is used extensively when drilling holes for rivets, screws, small bolts, and other small fasteners. But a 3/8- or 1/2-inch drill should be used to drill holes larger than 1/4 inch. Pneumatic drills are generally used when you are away from the shop; so be sure that you have an adequate supply of air available before proceeding with the job.

When using the hand pneumatic drill, hold it firmly and place a backup block of wood under the hole location (when possible) to add support to the metal. Insert the twist drill in the chuck and test it for trueness and vibration. You may check the trueness visibly by running the motor freely. Do not use a twist drill that wobbles or one which is slightly bent, because such a condition will produce enlarged holes.

Pneumatic drills are recommended for your use because most of your projects are located around flammable materials. Therefore, if you used an electric drill instead, sparks it produces will constitute a fire hazard. When you find access to a place where a hole is to be drilled difficult or impossible while you are using an ordinary drill, remember that various types of drill extensions and adapters are available to you. Thus, for example, a straight extension can be made from an ordinary piece of drill rod. You attach the twist drill to the drill rod by shrink

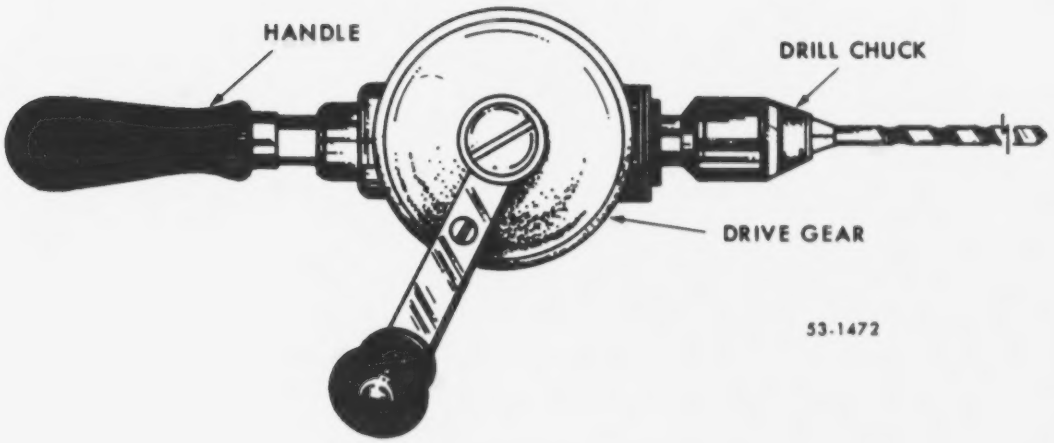


Figure 1-1. Hand drill.

fit, brazing, or silver soldering. Also, you can attach angle adapters to either an electric or a pneumatic drill when the location of the hole is truly inaccessible to a straight drill. Angle adapters have an extended shank which you fasten to the chuck of the drill. In use, hold the drill in one hand and the adapter in your other in order to prevent the adapter from spinning around the drill chuck. Furthermore, you can use a flexible extension (snake) for drilling in places that are inaccessible to ordinary drills. Its flexibility permits drilling around obstruction with a minimum of effort. CAUTION: Always wear safety goggles while drilling.

Drill Press. The drill press is a precision machine for drilling holes that require a high degree of accuracy. It serves as an accurate means of locating and maintaining the direction of a hole to be drilled, provides the operator with a feed control lever to regulate

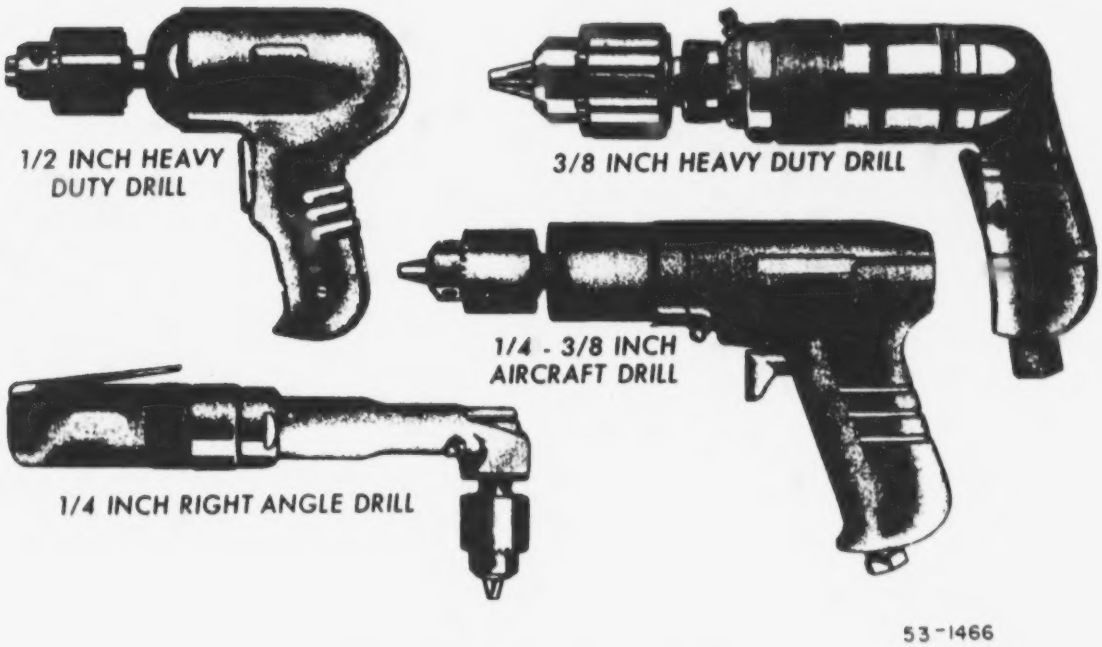


Figure 1-2. Types of portable pneumatic drills.

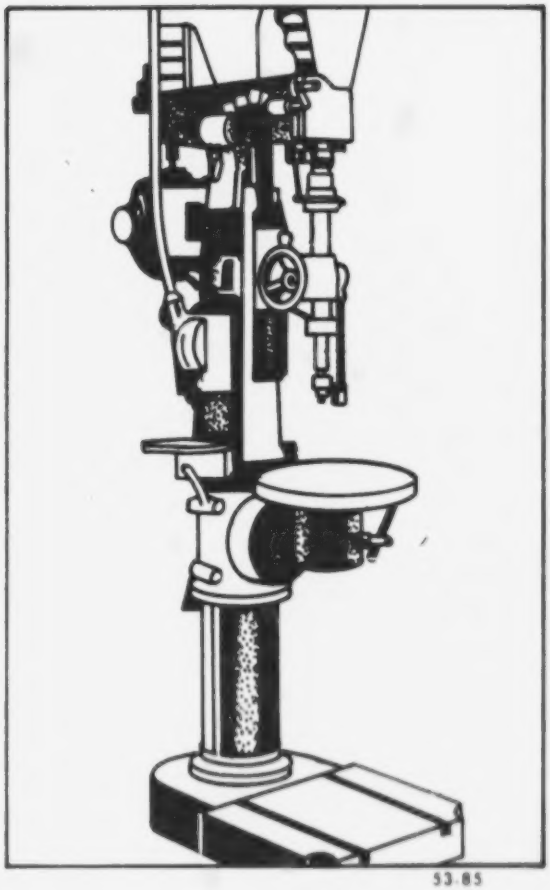


Figure 1-3. Drill press.

the drilling pressure, and makes the task of feeding the drill into the material easier. Among the many types of drill presses available, the most common type is the ordinary upright drill press, shown in figure 1-3. Take a few minutes and study the locations of its various parts, as shown in this illustration.

When you use a drill press, adjust the height of the working table to accommodate the height and thickness of the part to be drilled; then clamp the material into position, so that the center punchmark is directly in line with the twist drill. Material or parts that are not properly clamped may bind on the drill and start spinning. This could possibly cause the loss of your fingers or hands or leave serious cuts in your's or any other operator's arms or body. Therefore, always make sure that the part being drilled is properly clamped to the drill press before starting any drilling operations. As with other drills, you must always wear eye protection—goggles, safety glasses, or a face shield—while operating a drill press. However, with this piece of equipment, there is more danger to your eyes, because you work with smaller particles of metal.

Most drill presses are equipped with gears or multistep pulleys to provide a means of increasing or decreasing the speed of the spondle. Prior to changing the speed, you should stop a drill press. The drill press can be adjusted for different spindle speeds by changing the V-belt to different steps on the V-pulleys. Be sure to stop the motor before moving the belt from one step to another, and don't forget to check the belt adjustment before operating the drill press.

You should avoid continued heavy feed and excessive speed, because these will cause the machine to labor. These procedures may also cause twist drill breakage or damage to the machine. Speed of the chuck and rate of feed through the material vary, depending upon the material you are drilling. Check the manufacturer's handbook of the technical manual for information concerning the feeds and speeds recommended for various drilling operations. When drilling hard metal or steels, use a cutting oil to cool and prevent dulling of the twist drill. With proper feed and speed, the drill will usually produce a spiraled shaving; however, granular cuttings will be produced when drilling cast iron or other porous materials. To prevent binding or breakage, always reduce feed or pressure just before going through the metal.

Preventive maintenance for a drill press includes keeping it cleaned, adequately lubricated, and properly adjusted. Be sure that the belt guard is installed, that the V-belt has the correct tension, that the machine is clean, and that all parts operate and are serviceable. The motor of the drill press illustrated has sealed bearings and does not require oiling; however, the spindle and the depth adjustment feed handle have oil cups for lubrication. Lubricate the support column with an oiled rag to prevent corrosion and to allow the working table and head assembly to move up and down freely. Usually the V-belts on this type of equipment are adjusted to have a deflection of approximately 1/2 inch. Improper tension could cause a belt to break or fail to turn the spindle. To adjust the belt tension, loosen the belt adjustment nut; then tighten it after the proper distance between the pulleys has been obtained.

Exercises (400):

1. Give two situations in which you would use a hand drill.

2. Why are portable pneumatic drills recommended for use by an airframe repairman?

3. When would you have to use a drill press?

4. How can you tell when the V-belt on a drill press is adjusted properly?

5. What safety device is used when operating any type of drilling equipment?

401. Identify specific characteristics and parts of a twist drill and reamer, and state why certain selected parts of both are necessary "as is."

Twist Drills. Twist drills may be made of carbon steel or of high-speed alloy steel. However, although carbon steel twist drills are satisfactory for general work, if heated excessively, they lose their hardness. Still, high-speed steel drills may become very hot and still retain their temper. High-speed drills have the letters "HS" stamped on the shank to distinguish them from carbon drills. If you are drilling holes in hard or thick metal, it is desirable to apply a few drops of cutting oil in the hole to lubricate and to prevent excessive heating. If a cutting oil is used, high-speed twist drills will keep right on cutting even though they are hot. Excessive heating will also result from using a dull twist drill or from exerting too much or too little pressure on the twist drill. If a high-speed twist drill becomes overheated, it should be allowed to cool slowly. Do not cool an overheated high-speed twist drill in water, oil, or fast moving air because the metal may crack.

Twist drill sizes are expressed in terms of numbers, letters, and inches or fractions of inches, as shown in figure 1-4. The size is stamped on the shank of the twist drill. For example, a 3/16-inch twist drill, often used in sheet metalwork, has a decimal equivalent size of 0.1875 inch.

Figure 1-5 shows a twist drill with the nomenclature of its parts, including the shank, body, heel, flute, and land. A twist drill used for most operations has a lip angle of 59° and a heel angle of 12° to 15°. A lip angle of 68° is recommended for hard materials, such as stainless steel. Soft metals, such as brass or bronze, can be drilled with a twist drill having a lip angle between 50° to 60°. In sharpening a twist drill, both cutting edges must have the same lip angle and the same length cutting edge. The drill shank is the end that fits into the chuck of a drill motor or hand drill. The body of the part of the drill from the point to the shank, or from the point to where the flute ends. Flutes (channels) are designed in the drill to allow the chips, which are formed while drilling, to curl tightly and escape from the hole being drilled. These flutes also allow the lubricant to flow easily down to the lips of the drill, where it is needed as a coolant.

The lips (cutting edge) are the parts of the point which actually do the cutting. The drill axis, which runs from the center to the web to the extreme end of the shank, is the exact center of your drill. The web is the metal column which separates the flutes, and it is sometimes called the backbone of the drill. The point of a drill is the entire cone-shaped surface at the cutting edge. It should not be confused with the web. The heel is that part of a drill point just back of the cutting lips; its sole purpose is to allow the drill to work at its maximum effectiveness.

Generally, a twist drill for a given job should be selected according to the thickness, type alloy, and machine or drill to be utilized.

Reamers. Reamers are used to smooth and enlarge holes to exact size. Hand reamers have square end shanks, so they can be turned with a tap wrench or similar handle. A hole that is to be reamed to the exact size must be drilled about 0.003 to 0.007 inch undersize. A cut that removes more than 0.007 inch places too much load on the reamer and should not be attempted. As shown in figure 1-6, reamers are made of either carbon tool steel or high-speed steel. The cutting blades of a high-speed steel reamer lose their original keenness sooner than those of a carbon steel reamer; however, after the first superkeenness is gone, they are still serviceable. The high-speed reamer usually lasts much longer than does the carbon steel type. Reamer blades are hardened to the point of being brittle and must be handled carefully to avoid chipping them. When reaming a hole, rotate the reamer in the cutting direction only. Turn the reamer steadily and evenly to prevent chattering, marking, or scoring of the hole walls. Reamers are available in any standard size. The straight flute reamer is less expensive than the spiral flute reamer is, but the spiral type has the less tendency to chatter. Both types are tapered for a short distance back to the point to aid starting. Bottoming reamers have no taper and are used to complete the reaming of blind holes. For general use, an expansion reamer is the most practical. This type is furnished in standard sizes from 1/4 to 1 inch, increasing in diameter by 30 seconds. Each reamer has a maximum expansion of 1/21 inch. Taper reamers, both hand and machine operated, are used to smooth and true tapered holes and recesses.

Exercises (401):

1. Whether you are using a carbon steel or a high-speed alloy steel twist drill, what must you avoid to insure satisfactory results?

Size	Decimal Equivalent	Size	Decimal Equivalent	Size	Decimal Equivalent
1/2	0.500	3	0.213	3/32	0.0938
31/64	0.4844	4	0.209	42	0.0935
15/32	0.4688	5	0.2055	43	0.089
29/64	0.4531	6	0.204	44	0.086
7/16	0.4375	13/64	0.2031	45	0.082
27/64	0.4219	7	0.201	46	0.081
Z	0.413	8	0.199	47	0.0785
13/32	0.4062	9	0.196	5/64	0.0781
Y	0.404	10	0.1935	48	0.076
X	0.397	11	0.191	49	0.073
25/64	0.3906	12	0.189	50	0.070
W	0.386	3/16	0.1875	51	0.067
V	0.377	13	0.185	52	0.0635
3/8	0.375	14	0.182	1/16	0.0625
U	0.368	15	0.180	53	0.0595
23/64	0.3594	16	0.177	54	0.055
T	0.358	17	0.173	55	0.052
S	0.348	11/64	0.1719	3/64	0.0469
11/32	0.3438	18	0.1695	56	0.0465
R	0.339	19	0.166	57	0.043
Q	0.332	20	0.161	58	0.042
21/64	0.3281	21	0.159	59	0.041
P	0.323	22	0.157	60	0.040
O	0.316	5/32	0.1562	61	0.039
5/16	0.3125	23	0.154	62	0.038
N	0.302	24	0.152	63	0.037
19/64	0.2969	25	0.1495	64	0.036
M	0.295	26	0.147	65	0.035
L	0.290	27	0.144	66	0.033
9/32	0.2812	9/64	0.1406	67	0.032
K	0.281	28	0.1405	1/32	0.0312
J	0.277	29	0.136	68	0.031
I	0.272	30	0.1285	69	0.0292
H	0.266	1/8	0.125	70	0.028
17/64	0.2656	31	0.120	71	0.026
G	0.261	32	0.116	72	0.025
F	0.257	33	0.113	73	0.024
E-1/4	0.250	34	0.111	74	0.0225
D	0.246	35	0.110	75	0.021
C	0.242	7/64	0.1094	76	0.020
B	0.238	36	0.1065	77	0.018
15/64	0.2344	37	0.104	1/64	0.0156
A	0.234	38	0.1015	78	0.016
1	0.228	39	0.0995	79	0.0145
2	0.221	40	0.098	80	0.0135
7/32	0.2188	41	0.096	--	------

Figure 1-4. Twist drill sizes.

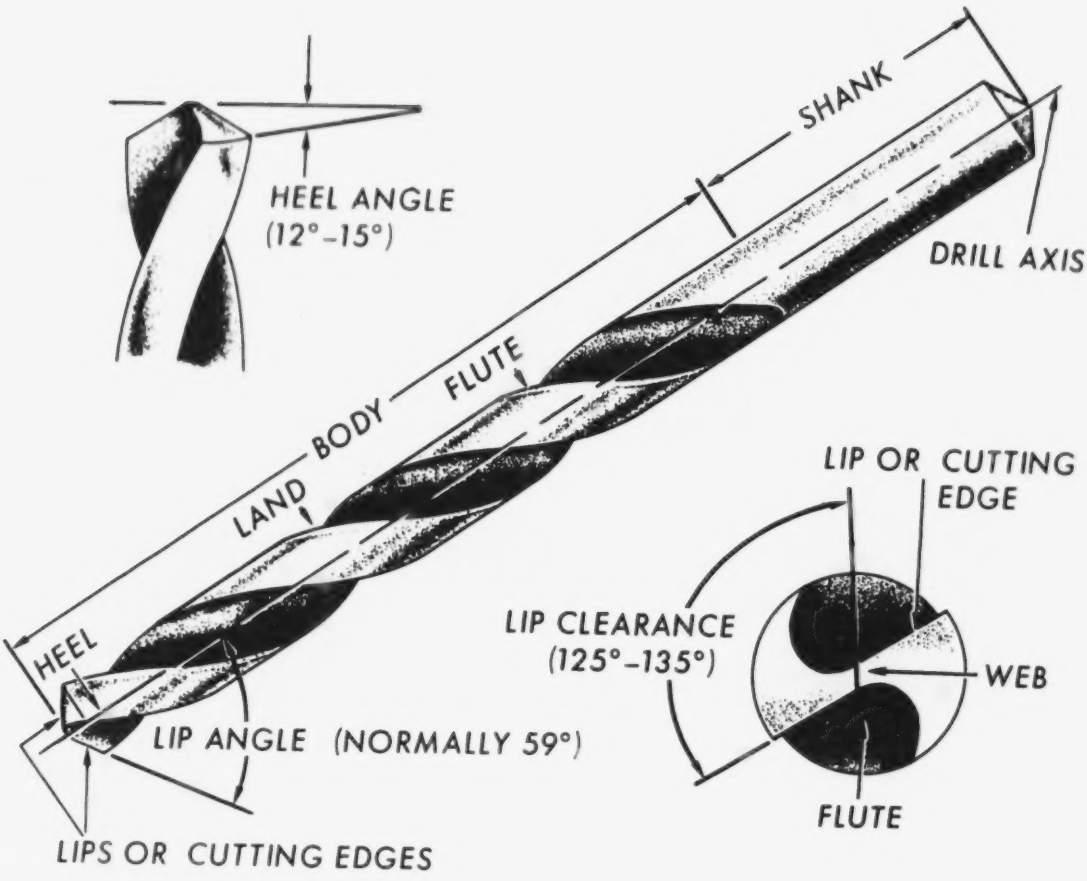


Figure 1-5. Twist drill nomenclature.

2. Why is it necessary that a high-speed steel twist drill not be cooled in water?

3. Is the following statement true or false? "The higher the twist drill number, the larger the diameter of the twist drill." Explain your answer briefly.

4. What part of a twist drill does the actual cutting?

5. Why are flutes necessary on a twist drill?

6. What is sometimes called the "backbone of twist drill"?

7. When would you have to use a reamer?

8. What physical property of reamers makes it necessary that they be handled carefully at all times?

9. Why is it necessary for bottom reamers to not be tapered?

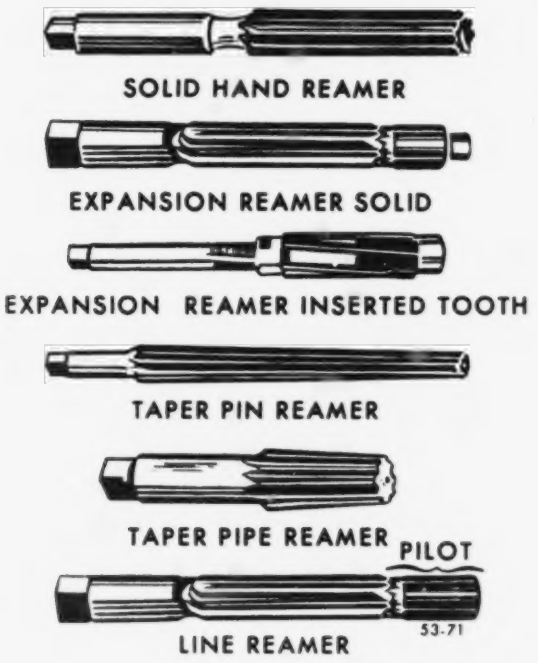


Figure 1-6. Types of reamers.

10. For general use, which type of reamer is the most practical?

402. Clarify drill-holding fixture procedures and state how the web thickness of a free-handed twist-drill sharpening is controllable and the way to insure proper grounding of this drill.

Correct twist drill grinding is an absolute requirement, simply because a sharp twist drill performs more efficiently than a dull one, and you can attain higher quality of work with less physical application on the drill with a sharp one. Beside, you cannot turn a twist drill in to supply because the point is dull. Why? Because drills at this time are classified as expendable items which can be replaced only after normal wear or breakage. Two methods of sharpening twist drills concern you as an airframe repairman—(1) the drill-holding fixture type and (2) free-hand grinding.

Drill-Holding Fixture. The exact procedure for grinding when using the drill-holding fixture varies with the make of the grinding machine or tool used. However, the following procedures are general and thus can be applied to most conventional type machines.

Place the drill in the V-blocks of the holder and turn the drill so that the cutting edge will contact the abrasive wheel as the drill is fed against the wheel, as figure 1-7 shows. Start the grinder and advance the tailstock until the drill makes contact with the abrasive wheel. Hold the drill in place in the V-blocks and swing the holder spindle slowly through its arc. Without changing the tailstock adjustment, revolve the twist drill one-half turn in the V-blocks and swing the holder spindle slowly through its arc. Without changing the tailstock adjustment, revolve the twist drill one-half turn in the V-blocks and sharpen the other lip of the twist drill in the same manner.

Inspect the drill point to see whether or not it has been ground back far enough to eliminate all nicks. Repeat the grinding and inspection operations until a perfect point is obtained.

Free-Hand Grinding. Free-hand grinding is done without the aid of any fixtures. The success of this operation depends upon your skill in using various techniques. Figure 1-8 illustrates the procedures discussed next.

Adjust the tool rest of the grinder to a convenient height for resting the back of your left hand while you are grinding. Hold the drill between the thumb and index finger of one hand and grasp the body of the drill near the shank with your other hand. Place your left hand on the drill rest, with the center line of the drill making the desired angle with the cutting face of the grinding wheel, and then slightly lower the shank end of the drill as illustrated.

There are two ways of rotating the drill when grinding— (1)counterclockwise and (2) clockwise. The method used depends upon the individual. When rotating the drill in a counterclockwise direction, slowly place the heel of the drill against the grinding wheel. Then gradually raise the shank end of the drill and

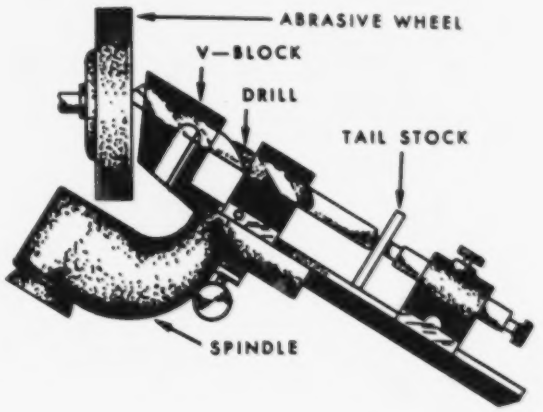


Figure 1-7. Drill-holding fixture.

twist it in your fingers in a counterclockwise direction while the grinding wheel contacts the cutting edge. Exert only enough pressure to grind the drill without overheating. Frequently cool the drill in water while grinding. As you rotate the drill in a clockwise direction, hold the drill in your right hand, with the point held against the grinding wheel at the proper angle. Your left hand should hold the body of the drill in the same manner as it was held for counterclockwise grinding. With the drill lip bearing against the grinding wheel, use your right hand to push the shank of the drill down and, at the same time, rotate the drill slightly clockwise and push it forward slightly. Remember to dip the drill in water often enough to prevent overheating. Check the results of the grinding with a gage or equivalent tool to determine whether or not the cutting edges are the same length and at the desired angle. Also notice the heel is ground to an angle of 12° to 15°.

The thickness of the web of a drill increases as the flute approaches the shank; this adds strength to the drill. As the drill point wears away through normal use, the web at the point becomes thicker. The web at the point should be no thicker than 1/32 or 1/16 inch. Web thickness can be controlled by grinding the web on a thin, round, or beveled edge wheel. If a suitable grinding wheel is not available, a coarse hand stone can be used. If you use a hand stone, hold the drill flat on the bench and then stroke the flute away from the point. Regardless of how the web is ground, be sure to remove the same amount of metal from each flute, and only enough to acquire a web thickness equal to that of a new drill the same size.

Exercise (402):

1. When using a drill-holding fixture to sharpen a twist drill, why is it necessary to rotate the twist drill one-half turn in the V-blocks after completing one arc?

2. How often must you rotate the twist drill in the V-blocks of a drill-holding fixture?

3. What factor determines which way the twist drill is rotated when sharpening a twist drill and not using a drill-holding fixture?

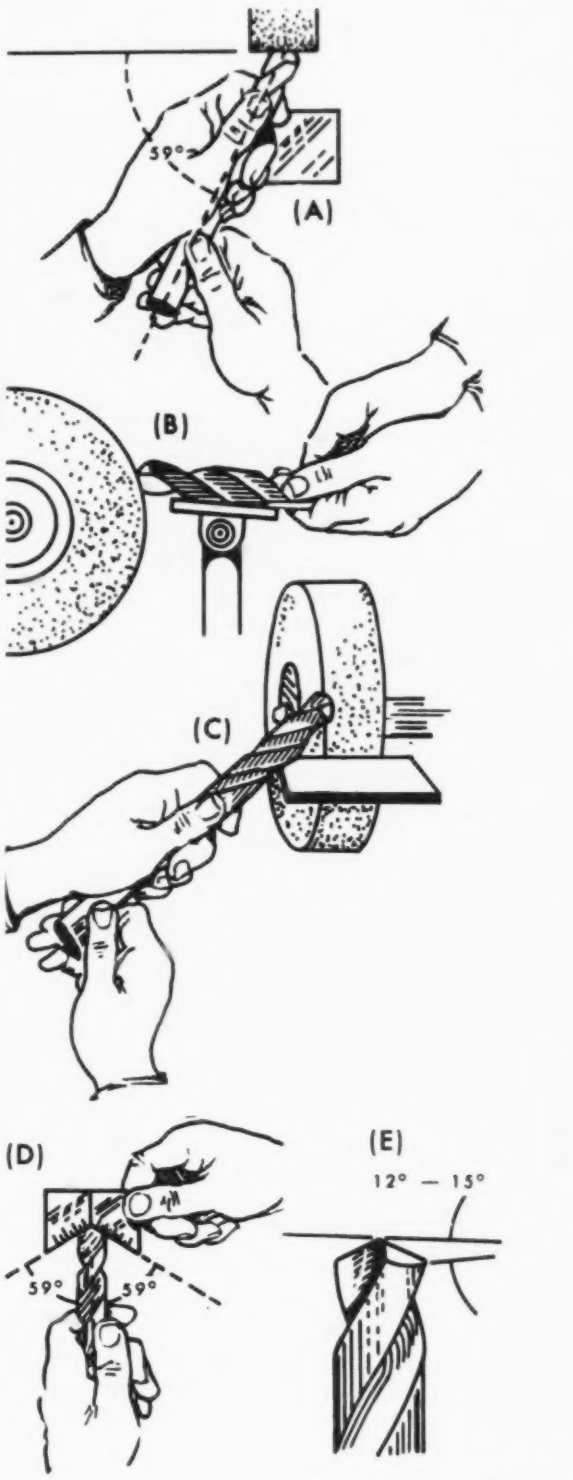


Figure 1-8. Free-hand grinding procedures.

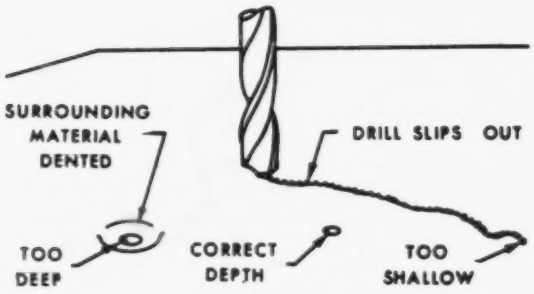


Figure 1-9. Center punching.

4. How can the web thickness be controlled when you are sharpening a twist drill free-handed?

5. What physical feature of a twist drill must you check after grinding to insure that the twist drill is ground properly?

403. Cite specified aspects of the methods used to drill holes for the installation of fasteners.

When you are drilling a hole with a twist drill installed in a hand or powered drill, the chuck must be tight enough to prevent slippage. The twist drill must make a hole with its center at the exact spot desired. You should therefore use a center punch to sink a mark deep enough to prevent the twist drill from "walking" away from the center point, as shown in figure 1-9. Be careful not to dimple the material by striking the center punch too hard. Next, secure the work and place the point of the twist drill into the punch mark. After beginning the drilling, always hold the drill at right angles to the work, as shown in figure 1-10, regardless of the position or curvature involved. By tilting the drill at any time when you are drilling into or withdrawing from the material, you may cause elongation (produce an egg-shape) of the hole. Consequently, you should ease the pressure the instant the twist drill breaks through the material but continue drilling until you have finished the hole.

When drilling is done through sheet stock, small burrs can be found around the edge of the hole. You must remove these burrs to prevent scratching and to allow rivets or bolts to fit snugly. You can do such removal of burrs with a countersink, a reamer, or a twist drill larger than the hole. If you use any of these to remove burrs, however, you should rotate it by hand.

To make a rivet hole of the correct size, first drill a hole slightly undersize. This process is known as predrilling, and the hole is called a pilot hole. The amount by which the diameter of a pilot drilled hole is smaller than that of the finished hole should be at least one-quarter of the thickness of the piece, and in no case should it be less than 1/32 of an inch. Ream the pilot hole with a twist drill of the correct size to get the required dimension. Pilot and reaming drill sizes are shown in table 1-1. The recommended clearance for rivet holes is 0.002- to 0.004 inch.

For hard metals, select a twist drill having an included angle of 118° and turn it at low speeds; whereas, for soft metals, use a twist drill having an included angle of 90° and turn it at higher speeds. Thin sheets of aluminum alloys can be drilled with greater accuracy by a drill having an included angle of 118°, because the large angle of the drill has less tendency to tear or elongate the hole.

While drilling, you must hold parts firmly together to insure alignment of the holes drilled. The most commonly used sheet metal holder is the Cleco fastener. This type of fastener is available in six different sizes: 332, 1/8, 5/32, 1/4, and 3/8 inch. The size is stamped on the fastener, and if the size marking

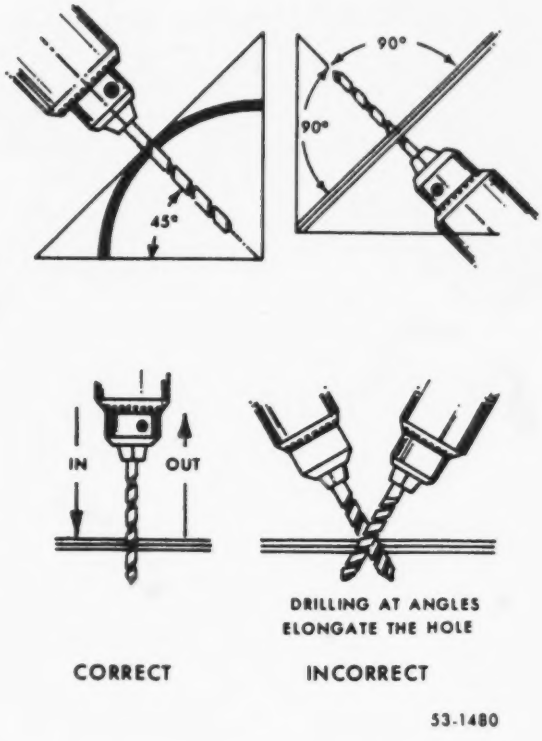


Figure 1-10. Drilling procedures.

TABLE 1-1
PILOT AND REAMING TWIST DRILL SIZES

Rivet Diameter	Pilot Size	Ream Size
3/32	3/32 (.0937)*	40 (.098)
1/8	1/8 (.125)	30 (.1285)
5/32	5/32 (.1562)	21 (.159)
3/16	3/16 (.1875)	11 (.191)
1/4	1/4 (.250)*	F (.257)
5/16	5/16 (.3125)	O (.316)
3/8	3/8 (.375	V (.377)

*Note that ream size exceeds the maximum tolerance of.004 inch. This is permissible only if the next larger drill size happens to be so much larger than the tolerance of .004 inch.

is missing, the fastener may be identified by its color. Notice, in figure 1-11, how a Cleco fastener is used to hold two sheets of metal together. Special pliers are used to insert and remove the Cleco in a drilled hole. One pair of pliers will fit the six different sizes. Table 1-2 illustrates the colored Cleco to use for a given rivet diameter.

Exercise (403):

1. What causes "walking" of a twist drill?

2. When should you release the drilling pressure required to drill holes?

3. If you had to drill fastener locations on a curved surface, how should you hold the drill in relation to the surface?

4. If, after drilling a hole, the hole is elongated, what did you do wrong?

5. What can you use to remove burrs from drilled holes?

6. Define the term "predrilling."

7. What is the largest permissible pilot hole size, if the final hole size is 5/32 of an inch?

8. If the rivet to be installed is 1/8 of an inch in diameter, would a 1/8-inch twist drill be satisfactory? Explain you answer briefly.

9. How can you reduce the possibility of misaligned holes when drilling holes?

10. Why are Cleco fasteners color-coded?

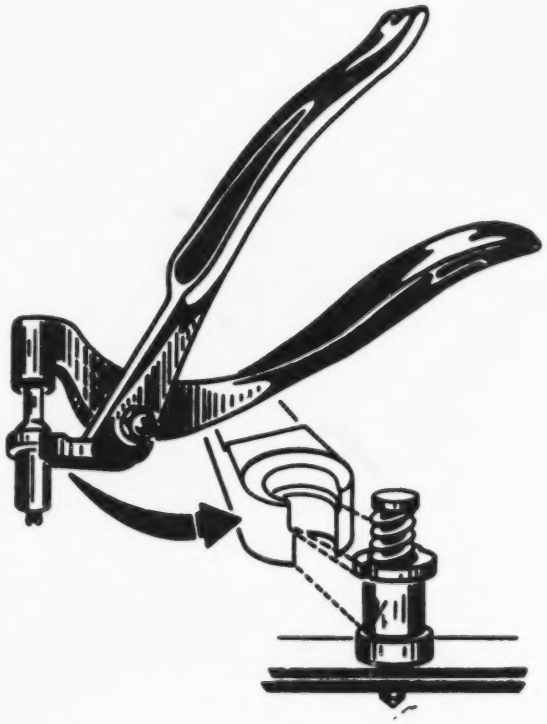


Figure 1-11. Cleco fasteners.

TABLE 1-2
CLECO COLOR CODES

Rivet Size	Drill Bit Size	Cleco Color Code
3/32	#40	Silver
1/8	#30	Copper
5/32	#21	Black
3/16	#11	Bronze
1/4	"F"	Copper

Note: The recommended clearance for rivet holes is .002 to .004 inch.

53-1471

404. State the countersink size determinants, causes of elongated holes, and hole type, and clarify countersink micro-stop increment and how to insure hole gripping surface.

An improperly made countersink reduces the strength of a flush-riveted joint and may cause failure of the sheet or the rivet head. Let's take a look at the tools and procedures used to countersink holes.

Countersinks. The countersink is a tool which cuts a cone-shaped depression around the rivet hole to allow the rivet to set flush with the surface of the skin. Countersinks are made with various angles to correspond to the various angles of the countersink rivet heads. For example, the angle of the standard countersink, shown in figure 1-12, is 100°. Special stop countersinks are available. Stop countersinks like that in figure 1-12 are adjustable to any desired depth, and the cutters are interchangeable so that holes of various countersunk angles may be made. Stop countersinks have a micrometer set arrangement, in increments of 0.001 inch, for adjusting the cutting depths.

Figure 1-13 illustrates general rules for countersinking. In the top example, note that the material is quite thick and that the head of the countersunk rivet extends only about halfway through the upper layer of metal. Countersinking will leave plenty of material for gripping; buckling of the material is out of the question.

In the middle example, the countersunk head reaches completely through the upper layer. This condition is permissible but is frowned upon.

In the bottom example, the head extends well into the second layer of material. This indicates that the material is thin and that most of it would be ground away by drill countersinking; therefore, dimpling is preferred.

Procedure. Machine or drill countersinking is accomplished by a suitable cutting tool, machined to the desired angle, which cuts away the edge of the hole so that the countersunk head rivet fits snugly into the recess. The resulting process is referred to as the "well" or "nest."

During the process of machine countersinking, first drill the original rivet hole to the exact rivet size. The limits within which the head of the rivet may extend either above or below the surface of the metal are close. Therefore, perform the countersinking accurately, using equipment capable of producing results within the specified tolerance.

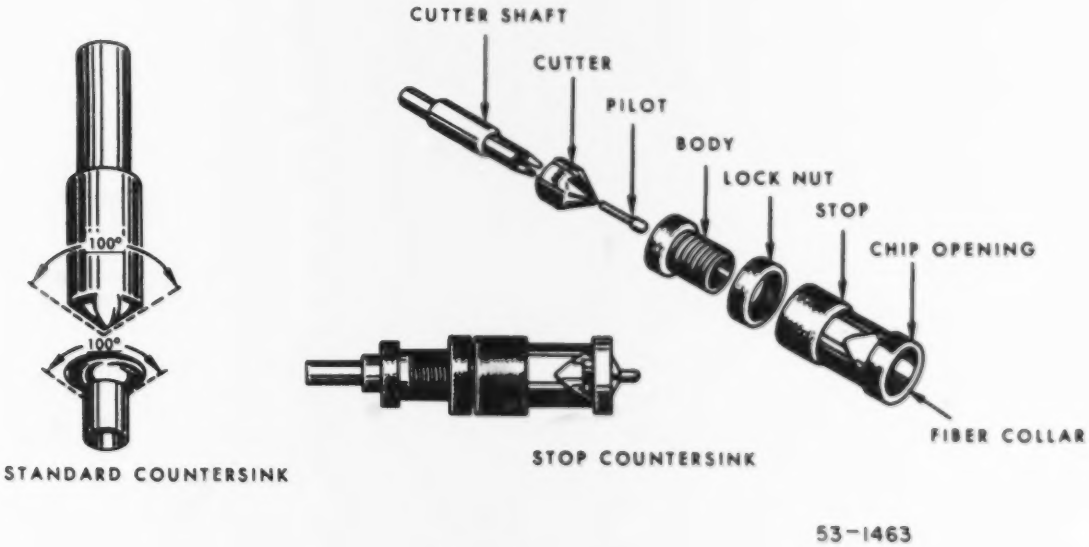


Figure 1-12. Countersinks.

Diameter of rivet (in.)	Top sheet thickness (in.)	Under sheet thickness (in.)	Use countersink method
3/32	0.032 or greater		a
	0.025 or less	0.051 or greater	b
	0.025 or less	0.040 or less	c
1/8	0.040 or greater		a
	0.032 or less	0.064 or greater	b
	0.032 or less	0.051 or less	c
5/32	0.051 or greater		a
	0.040 or less	0.072 or greater	b
	0.040 or less	0.064 or less	c
3/16	0.064 or greater		a
	0.051 or less	0.091 or greater	b
	0.051 or less	0.081 or less	c

a Machine countersink (cut) top sheet.
b Press countersink (dimple) top sheet, and machine countersink under sheet(s).
c Press countersink (dimple) top and under sheets.

53-1475

Figure 1-13. Countersinking standards.

Hold the countersinking tool firmly at right angles to the material. Do not tip it. Why? Because tipping elongates the well and prevents the countersunk rivet head from fitting properly. Oversized rivet holes, undersized countersink pilots (in the case of the stop countersink), chattering caused by improper use of the stop countersink or by a countersink in poor condition, and a countersink not running true in the chuck of the drill are some of the causes of elongated wells.

When using a micro-stop countersink, always provide some sort of backside guide for the pilot on the countersink. The lack of a backside guide will, in most cases, produce elongated wells.

Exercises (404):

1. What two factors determine the size of countersink to use?

2. Each increment on a micro-stop countersink represents how many thousandths?

3. How can you insure that countersunk holes have plenty of gripping surface?

4. State four causes of elongated holes when countersinking.

5. What factors determine whether fastener holes are countersunk or dimpled?

405. Give specific applications, limitations, and results involving the methods developed to dimple holes, and give the construction features of the tools required.

Dimpling can be accomplished by either of two methods: (1) hand dimpling and (2) thermo dimpling. In either case, the metal immediately surrounding the rivet hole is pressed into the proper shape to fit

the rivet head. The depression thus formed, as in machine countersinking, is known as the well or nest. The rivet must fit the well snugly in order to obtain maximum strength. The number of sheets which can be dimpled simultaneously is limited by the capacity of the equipment used.

Hand Dimpling. Hand dimpling can be accomplished by your either using dimpling dies (a male and female set) or using a rivet as the male die and the female die. The dimpling dies are made to correspond to any size and degree of countersunk rivet head available. The dies are usually numbered, and the correct combination of punch and die to use is indicated on charts specified by the manufacturer. Both male and female dies are machined accurately and have highly polished surfaces. The male die or punch is cone-shaped to conform to the rivet head and has a small concentric pilot shaft that fits into the rivet hole and female die. The female die has a corresponding degree of countersink into which the male guide fits.

When dimpling a hole, rest the female die on some solid surface, place the material on the female die, insert the male die in the hole to be dimpled, and then hammer the male die. Strike with several solid blows until the dimple is formed.

In some cases, the face of the male die is convex to allow for springback in the metal. Dies of this type are used to advantage when the sheet to be dimpled is curved. However, some dies have flat faces and are principally used for flat work. Dimpling dies are usually so made that their included angle is 5° less than that of the rivet. This arrangement allows for springback of the metal.

In die dimpling, the pilot hole of the female die should be smaller than the diameter of the rivet to be used. Accordingly, the rivet hole must be the exact diameter after the dimpling operation has been completed, so that the rivet fits snugly.

When using a countersunk rivet as the male dimpling die, place the female die in the usual position and back it with a bucking bar. Place the rivet of the required type into the hole and strike the rivet with a pneumatic riveting hammer. This method of countersinking is often called coin pressure. It should be used only when the regular male die is broken or not available.

Coin pressing has a distinct advantage in that the rivet hole must be drilled to correct rivet size before the dimpling operation is accomplished. Since the metal stretches during the dimpling operation, the hole becomes enlarged and the rivet must be swelled slightly before driving to produce a close fit. Because the rivet head will cause slight distortions in the recess and because these are characteristic only to that particular rivet head, it is wise to drive the same rivet that was used as the male die during the dimpling process. Do not substitute another rivet, either of the same size or a size larger.

Thermo Dimpling. This type of dimpling has only recently been developed into an efficient method. It consists of two processes: (1) radius dimpling and (2) coin dimpling. The major difference between radius and coin dimpling lies in the construction of the female die. For coin dimpling, use a sliding ram female die, such as illustrated in figure 1-14. It is this sliding coining ram that makes the coin dimpling process superior.

During the coin dimpling process, the metal is coined (made to flow) into the contours of the dies, so that the dimple assumed the true shape of the die. The pressure exerted by the coining ram prevents the metal from compressing and thereby assures uniform cross-sectional thickness of the sides of the dimple and a true conical shape.

Coin dimpling offers several advantages. It improves the configuration of the dimple, produces a more satisfactory aerodynamic skin surface, eliminates radial and circumferential cracking, insures a stronger and safer joint, and allows identical dies to be used for both skin and understructure dimpling.

The coin ram dimplings dies are designed with a number of built-in features. The faces of both the male and female dies are dished (the male, concave; and the female, convex) at an angle of 2° on the pilot. This facilitates removal of the metal after the dimple has been made.

The female dimpling set has two parts: (1) the body, which is merely a counterpart of the male die; and (2) the coining ram, which extends up through the center of the conical recess of the body. In forming a dimple, force the metal down into the female die by the male die. The metal first contacts the coining ram, and this supports the metal as it is forced down into the conical recess. When the two dies close to the point where the forces of both are squeez-

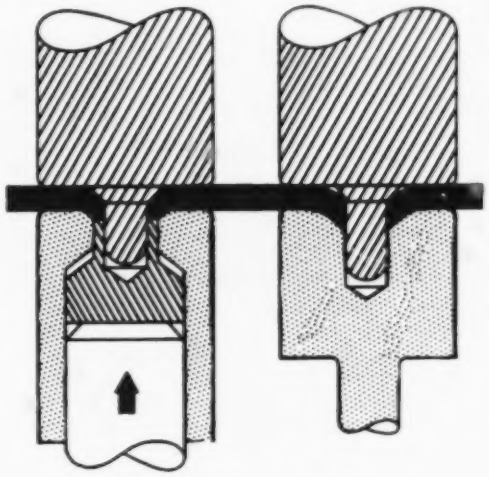


Figure 1-14. Radius and coin dimpling dies.

ing the material, the coining ram forces the metal back into the sharp corners of the dies.

When cold dimpling, use the dies alone; whereas, when hot dimpling, slip a strap or block heater over either or both dies and connect them to an electric current.

You should keep the dies clean and in good working order at all times. It is advisable for you to clean them regularly, using steel wool. But you must take special precautions when the dies are in the machines. The reason is that if the machine is operated with the dies in place but without material between them, the male die will enlarge and ruin the coining ram.

Dimpling materials. The material being used is a very important factor to consider in any dimpling operation. Such materials as corrosion-resistant steel, magnesium, and titanium each present different dimpling problems.

The 2024T aluminum alloy can be satisfactorily coin dimpled by either the hot or the cold method. However, cracking in the vicinity of the dimple may result from cold dimpling, because of hard spots in the metal, whereas hot dimpling will prevent such cracking.

The 7075-T6 and 2024-T81 aluminum alloys are always hot dimpled. Magnesium alloys also must be hot dimpled because, like 7075-T6, they have low formability qualities. Titanium is another metal that must be hot dimpled, because it is tough and resists forming. The same temperature and dwell time used to hot dimple 7075-T6 is used for titanium.

Corrosion-resistant steel is cold dimpled, because the temperature range of the heating unit is not high enough to affect dimpling.

Types of thermo dimpling equipment. There are two types of thermo dimpling equipment: (1) stationary and (2) portable. The most commonly used are the CP 450EA stationary dimpler, seen in figure 1-15, and the CP 351 portable squeezer, seen in figure 1-16. Portable dimplers are usually controlled by the ZT 1809C portable control panel. Control panels are used for all thermo dimpling. They insure fully automatic cycling, heating, and timing control at all times.

The CP 450EA stationary dimpler, as shown in figure 1-15, is used to dimple large pieces of either ferrous or nonferrous aircraft metal up to 1/8-inch thick. The squeezing action is pneumatically controlled, while the dwell time is electrically controlled. The dimpling cycle is operated by a foot switch, so that both hands of the operator are free to hold the work being dimpled. This machine can be operated either for hot or cold dimpling. DANGER: Do not hold small metal parts with your hand while hot dimpling. The metal or hot dies will burn your hands. Also, you should use a test strip when making pressure adjustments. Figure 1-17 illustrates the results of different pressure settings.

When possible, coin dimpling should be performed on stationary equipment and before the assembly of parts. However, many instances arise in which dimpling must be done after parts are assembled to other structures. In such cases, dimpling operations are performed on portable squeeze dimplers. Most squeezers may be used for cold dimpling or combined with a junction box for hot dimpling.

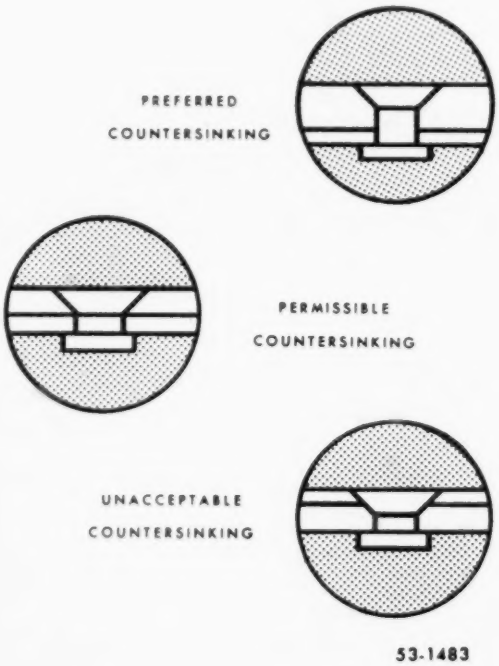
There are dimpling applications in which it is not possible to accommodate any squeezer or yoke type equipment. Under these circumstances, it is necessary for you to use a pneumatic hammer and a bucking bar type of tool to hold the dimpling dies.

Selection Factors. Dimpling will work best if the material is not over 0.0040 inch thick. As a general rule, you should dimple the material when the thickness of the material is thinner than the thickness of the rivet head. For thicker material, use the countersinking method. Table 1-3 offers guidelines to follow when dimpling or countersinking is required. Other factors to consider are the height and angle of the countersink head, the tools available, and the accessibility.

Exercises (405):

1. Why do dimpling dies have an included angle of 5° less than that of the rivet being installed?

TABLE 1-3
COUNTERSINKING GUIDELINES



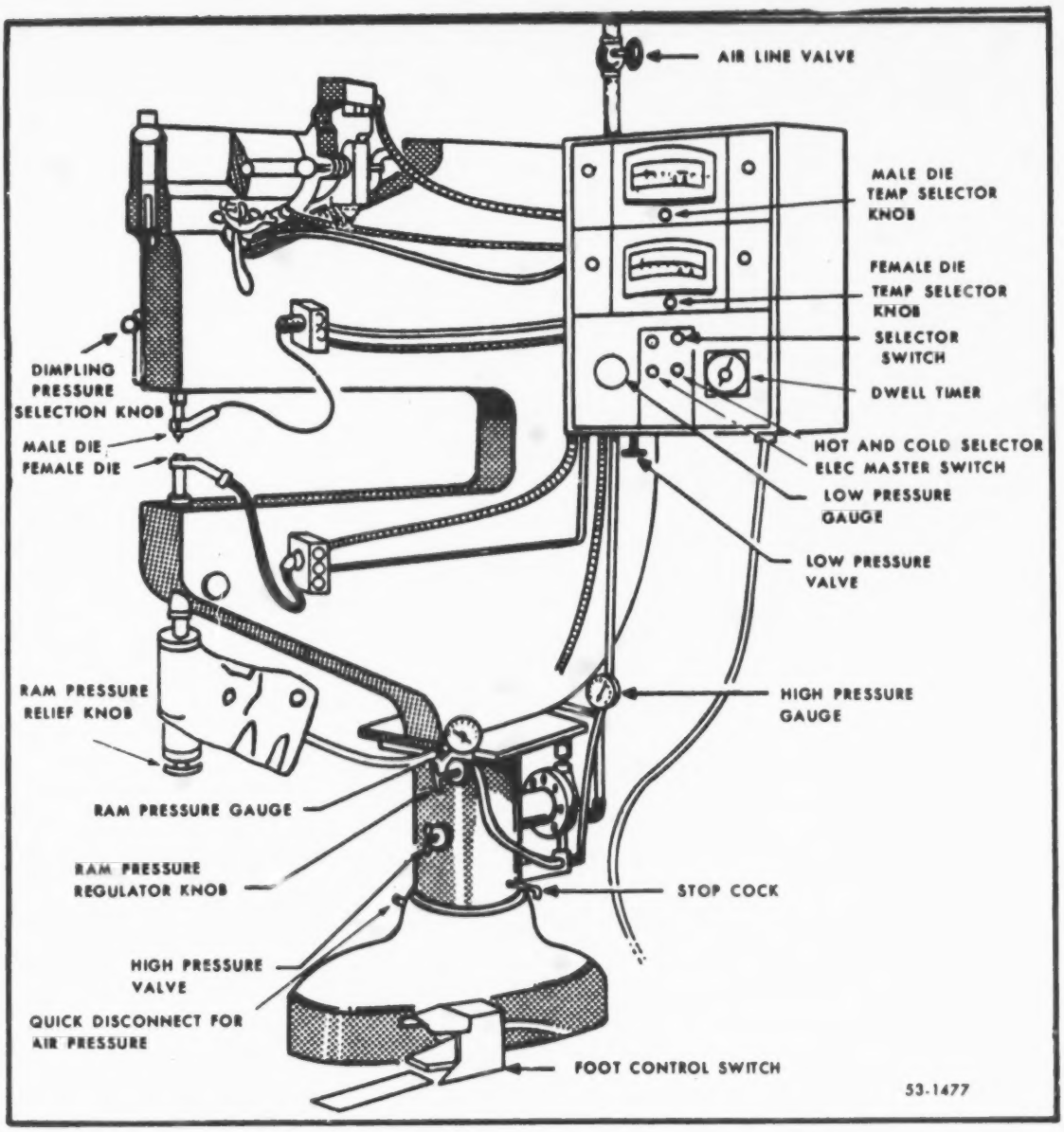


Figure 1-15. CD 450EA stationary dimpler.

2. Describe briefly the coin pressing method of dimpling holes.

3. How can you overcome the problem created by the coin pressing method of dimple holes?

4. In hand-dimpling holes, using dimpling dies, when are the holes reamed to the correct size?

5. What is the major difference between radium and coin dimpling?

6. Why are the dimpling dies used for coin dimpling dished?

7. What results when coining ram dies are operated without material being placed between them?

8. If 2024T aluminum alloy can be either hot or cold dimpled, why is hot dimpling recommended?

9. Why is corrosion-resistant steel cold dimpled?

10. What is the general rule to follow when determining whether or not holes should be dimpled or countersunk?

1-2. Riveting Procedures

A rivet is a metal pin used to hold two or more metal sheets, plates, or pieces of material together. A head is formed on one end when the rivet is manufactured. The shank of the rivet is placed through matched holes in two pieces of material. The tip is then mushroomed to form a second head to clamp the two pieces securely together. The second head, formed either by hand or by pneumatic equipment, is called a "shop head"; it serves the same purpose as a nut on a bolt.

Thousands of rivets are necessary in the building of modern aircraft. For example, more than 150,000 are required in the construction of a medium bomber, and nearly half a million are needed in a large bomber. These figures indicate the importance of rivets and riveting. As an airframe repairman, you must be a skilled riveter and have a thorough knowledge of the various types of rivets and their uses. You must be able to identify head shapes and alloy composition and to select the correct rivet for a given job.

406. State characteristics, ways, purposes, and procedures in using solid rivets.

Many types of rivets are available. A type of rivet exists for nearly every location and kind of structural stress encountered in aircraft construction. You are not expected to be a structural engineer, but you are expected to know where and when to use rivets normally found in an airframe repair shop.

Rivet Material. Except under unusual conditions, rivets should be used only for the type of application for which they are designed. In aircraft structural repair procedures, the same type of rivets should be used as in the original manufacture. Choice of materials is dependent upon these three factors: (1) usage, (2) corrosion resistance, and (3) strength.

Rivet general uses. The 1100-F alloy rivet, made of pure aluminum, is used for riveting nonstructural parts fabricated from the softer aluminum alloys, such as 1100-F, and 5052. The 2117-T4 alloy rivet is the rivet most commonly used in aluminum alloy structures. The main advantage of this latter rivet is that it may be used without further treatment, either heat or otherwise. The 2017-T4 and 2024-T alloy rivets are used in aluminum alloy structures where strength greater than that provided by the 2117-T4

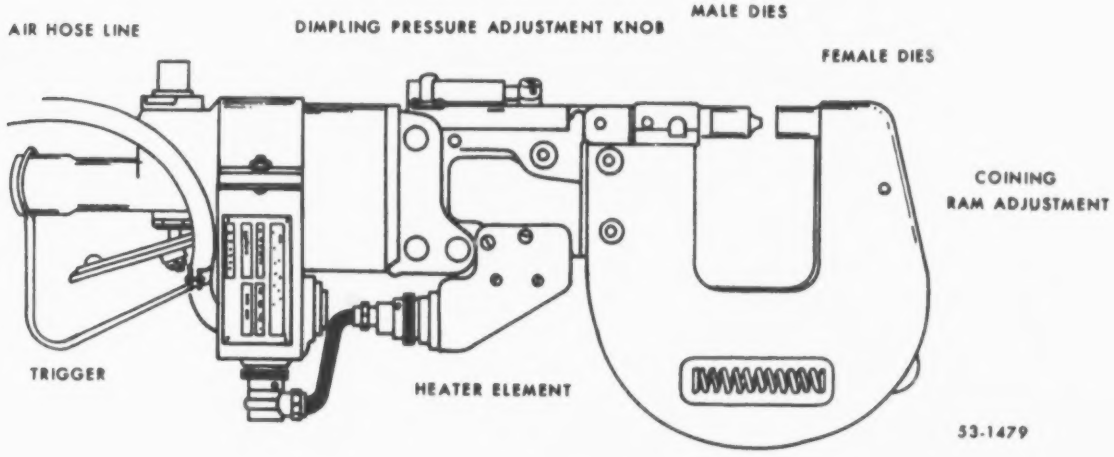


Figure 1-16. CD351 portable squeezer.

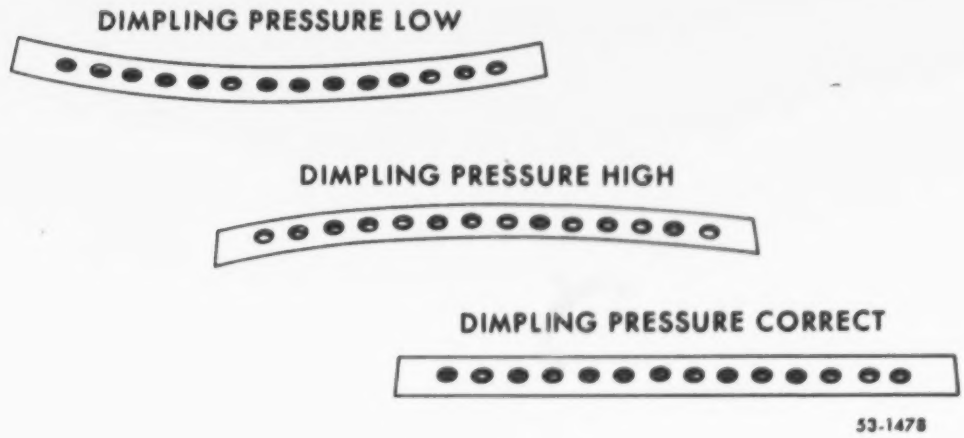


Figure 1-17. Dimpling pressure results.

rivet is required. These rivets are generally of 3/16-inch diameter size and larger. The 5056–H32 alloy rivet is used for riveting magnesium alloy structures, because of its corrosion resistant qualities when used with magnesium. Other rivets should not be used with magnesium, except in emergencies. Why? Because they produce an adverse corroding condition when used in this way. Mild steel rivets are used primarily in riveting steel parts. Galvanized rivets should never be used on steel parts subject to high heat. Corrosion-resistant steel rivets are used primarily in riveting corrosion-resistant steel parts, such as firewalls, exhaust stack bracket attachments, and similar structures. Monel rivets are used for riveting high nickel steel alloys and nickel alloys. These monel rivets may be used interchangeably with stainless steel rivets; however, it is better to use stainless steel rivets in stainless steel parts. Titanium rivets are used in high performance aircraft, where weight, shank, and hole tolerances are critical. Titanium rivets have high tensile strength with low weight, as well as resistance to heat and corrosion. Copper rivets are used for riveting copper alloys, leather, and nonmetallic materials. These rivets have limited usage in aircraft.

Rivet corrosion resistance. In general, corrosion resistance is adequate when the rivet material is the same or nearly the same as that of the structure being riveted, provided the proper anticorrosion treatment has been applied. Anodized 2117–T4, 2017–T4, and 2024–T4 rivets may be used to rivet any aluminum alloy structure without producing corrosion. Certain aluminum alloys react to each other and, therefore, must be considered as dissimilar metals. The commonly used aluminum alloys may be divided into the two groups as follows:

- Group A—1100, 3003, 5052, and 6053
- Group B—2017, 2024, 2117, and 7075

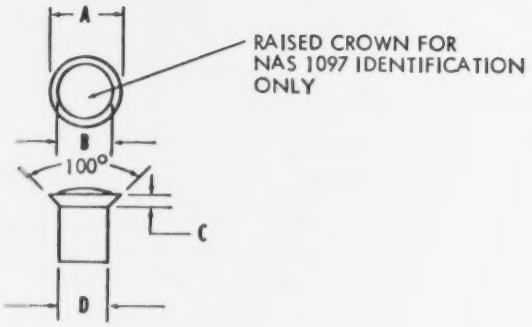
Members of either group A or group B can be considered as similar to each other and will not react to others within the same group. A corroding action will take place, however, if any metal of group A comes into contact with a metal in group B in the presence of moisture. Therefore, avoid the use of dissimilar metals whenever possible. To comply with military standards (MS), the manufacturers must put a protective surface coating on the rivets. This may be of zinc chromate, metal spray, or an anodized finish. The protective coating on a rivet is identified by its color. A rivet coated with zinc chromate is yellow, an anodized surface is pearl grey, and the metal-sprayed rivet is identified by a silvery gray color. If an emergency arises where a protective coating must be applied on the job, paint the rivet with zinc chromate before it is used and again after it is driven.

Dangerous corrosion will result if steel, corrosion-resistant steel, Monel, titanium, copper, or iron rivets are used in riveting aluminum structures. Such applications should be confined to extreme emergencies. In such cases, one coat of zinc chromate primer should be applied to the rivet before and after installation. Proper replacement should be made as soon as materials are available.

Shape. Rivets are manufactured in several different head styles, among which are these: (1) roundhead, (2) flathead, (3) brazier-head, (4) universal head, (5) standard, and (6) the shear head type countersunk style.

Universal head. The universal head is a combination of the roundhead, flathead, and brazier-head, all of which have protruding heads. It is used in aircraft construction and repair in both interior and exterior locations. When protruding head rivets must be replaced, they can be replaced with universal-head rivets.

Standard countersunk head. The countersunk-head rivet is flat-topped and beveled toward the shank. It will fit into a countersunk or dimpled hole and lie flush with the surface of the material. The angle at



NOTE

ALLOY IDENTIFICATION IS THE SAME FOR THE SHEAR HEAD (NAS1097) RIVET AS FOR THE STANDARD (MS20426) RIVET.

RIVET TYPE	RIVET DIA	DIMENSIONS		
		A	B	C
NAS 1097 SHEAR HEAD	1/8	0.192	0.139	0.029
	5/32	0.243	0.190	0.037
	3/16	0.299	0.203	0.046
MS20426 STANDARD	1/8	0.255	——	0.042
	5/32	0.266	——	0.055
	3/16	0.353	——	0.070

53-1536

Figure 1-18. Shear head countersunk Rivet.

which the sides slope may vary from 78° to 120°. Generally, manufacturers are standardizing on the 100° countersunk head. These rivets are used to fasten sheets over which other sheets must fit. They are also used on exterior surfaces of the aircraft, because they offer only slight resistance to the slipstream and help minimize turbulent airflow.

Shear head countersunk head. Shear head rivets are characterized by a reduced head diameter and thickness when compared with the same diameter standard countersunk head. Figure 1-18 compares both of these latter types of countersunk heads. A raised crown is on the top of the head for identification purposes only. Material composition is indicated by the same head marking as that used on the standard countersunk head.

The primary use of this rivet is to attach skin panels by the use of countersunk holes. Due to the thin head of the rivet, countersinking can be used in thinner sheet gages than for the standard countersunk head.

Dimensions. The diameter, length, and angle of countersunk are the three factors concerned with the dimension of solid rivets. The diameter is measured in 1/32nds of an inch. The following are the most commonly used rivet diameters: 3/32 inch, 1/8 inch, 5/32 inch, 3/16 inch, and 1/4 inch. The length is measured in 1/6ths of an inch. The length of countersunk head rivets is measured from the top of head to the bottom of the shank. Universal head rivets are measured from the bottom of the head to the bottom of the shank. The angle of countersunk is measured in degrees, and will vary from 78° to 120°. Figure 1-19 illustrates the three methods of measuring the size of a solid rivet.

Substitution Allowances. Substitution of rivets depends upon the material, size, and head style involved. Material considerations must be followed in substituting one rivet material for another. Thus, where replacement of aluminum alloy rivets is necessary, the universal head rivets should be used to replace roundhead, flathead, and brazier head rivets. Countersunk rivets must be replaced by rivets of the same type and degree of countersunk. If the required countersunk rivet heads are not available, a raised

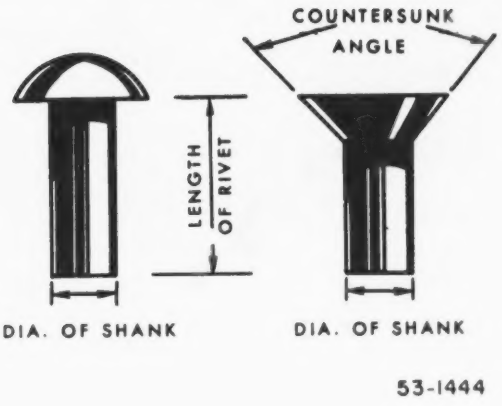


Figure 1-19. Methods of measuring rivets.

head rivet may be driven from the opposite side and upset into the countersink. Care must be taken in this operation to keep the flat surface of the tools parallel to the work. Rivet length should be such that both the hole and the countersink are completely filled. If this procedure is impractical, the drilled-out rivet head may be used as a washer, and a universal head rivet may be inserted and driven in the normal manner. In this procedure, you must take care to drill the hole in the center of the countersunk rivet head. NOTE: The procedures outlines here should be confined to interior work and should not be used in exterior applications on flush-riveted skin surfaces.

The same diameter and type rivets in "D" and "DD" alloys may be substituted for "AD" alloy standard rivets on a one-to-one basis. This substitution will not apply when replacing standard rivets in castings or fittings unless approved by the aircraft structural design officer and when an oversize hole condition which involves using the next larger diameter rivet exists. Substitution of less strength rivet allows, such as "B" for "AD," "B" or "AD" for "D," and "D" for "DD" is not permitted. Approval of the aircraft structural design officer must be obtained before this type of substitution can be made. This type of substitution usually involves an increase in the number of substitute fasteners to be installed and presents installation problems where an existing row of rivets already exists.

Do not enlarge the countersink for a shear head type countersunk rivet to accept a standard countersunk type rivet. Why? Because if carried out, this procedure would violate the minimum surface sheet thickness for countersinking. The same diameter and alloy standard countersunk rivet should be driven into the existing or prepared hole for the same diameter shear head rivet and shaved flush.

Exercise (406):

1. In what type parts are you likely to use aluminum alloy 1100F rivets?
2. Name the ways solid rivets are measured.
3. When are aluminum alloy 2017-T4 rivets used in place of 2117-T4 alloy rivets?
4. How does a standard countersunk rivet differ from a shear head countersunk rivet?
5. What type of rivets should be used in nickel steel alloys?
6. What is the ratio of substitution when replacing "AD" rivets with "D" or "DD" rivets?
7. Besides being structurally weaker, what other problem is created when "D" rivets are replaced with "AD" rivets?
8. How and when is a universal head used to replace a countersunk head rivet?
9. Why is it not permissible to replace a shear head countersunk rivet with a standard countersunk rivet?
10. What procedure is used to replace, if need be, a shear head countersunk rivet with a standard head countersunk rivet?

407. State the solid rivet features, head marking code, color code, and code number meaning involved in selected situations.

It would be impossible to differentiate among the various material compositions of rivets, if it were not for the markings found on the head of each rivet. Accordingly, you must be able to recognize these head markings so that you can select the correct rivet for the right job. Along with head marking, code numbers have been developed which are necessary when

ordering rivets and researching repair procedures in technical orders. Let us take a close look at both of these systems used to identify rivets.

Head Markings. The markings on the head rivets indicate the materials of which they are made and their strength. Table 1-4 identifies the rivet head marking and the material of which they are made. You will notice that the head markings are the same for both universal and countersunk rivets. There are three materials indicated by a plain head; yet it is possible to distinguish their difference by color. The 1100 is aluminum color; the mild steel is a typical steel color; and the copper rivet is a copper color.

Different markings on the heads of rivets are also used to classify their characteristics. These markings may be in the form of either a raised teat, a dimple, a pair of raised dashes, a raised cross, or a single triangle, although some rivet heads have no markings. The different markings indicate the composition of the rivet stock. The rivets are also different in color. This was explained previously as a means of identifying the protective surface coating used by the manufacturer. TO 1-1A-8, *Structural Hardward,* contains a listing of all head markings used for all fasteners.

Code Number. Each type of rivet is identified by a part number, so that you will be able to select the proper rivet for the job. These part numbers are in series, and each series represents a particular type of head. For example, the part number MS20426 means that the rivet is a military standard and has a 100° countersunk head.

There are also letters and numbers added to a part number. The letters designate alloy content; the numbers, rivet diameter and length. A letter, or letters, following the basic military standard (MS) number indicates the rivet material composition. The absence of a letter indicates that the rivet is manufactured from carbon or mild steel. The first dash number designates diameter of the rivet in thirty-seconds of an inch, and the second dash number designates the length of the rivet in sixteenths of an inch. An example of a complete rivet part number is shown in table 1-4.

Aluminum and aluminum alloy rivets are also packaged in boxes bearing colored labels. The color of the label will indicate the composition of the rivets inside the box. The rivets and the corresponding label color are 1100, white; 2117-4, orange; 2017-T4, yellow; 2024-T4, red; and 5056, blue.

Exercises (407):

1. What physical feature of solid rivets indicates the material composition of the rivet?
2. In the space provided, place the material code indicated by the head marking:
   a. Raised cross _____
   b. Raised teat _____
   c. Dimpled _____
   d. Raised double dash _____
   e. Recessed double dimple _____
3. In the space provided, indicate the meaning of each portion of the rivet code number MS 20427-D-4-10:
   a. MS _____
   b. 20427 _____
   c. D _____
   d. 4 _____
   e. 10 _____
4. Where would you look to find the meaning of an unknown head marking?
5. What is indicated by the color-coding used on boxes of solid rivets?

408. Identify specified factors relating to temperature involving heat-treated rivets and give the time periods involving cold storage and room termerature affecting such rivets and the reason for cold-storing such rivets.

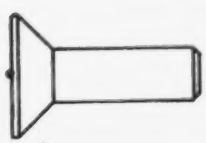
Heat-Treating of Icebox Rivets. Temper is an important factor to the riveting process, especially with aluminum alloy rivets. Such rivets have the same heat-treating characteristics as aluminum alloy sheet stock. They can be hardened and annealed in the same manner as can sheet aluminum. However, the rivet must be soft, or comparatively soft, before a good shop head can be formed. The 2017 and 2024-T4 rivets are heat-treated before being driven. They harden with age.

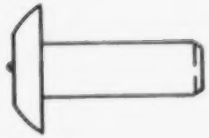
The process of heat-treating rivets is much the same as that of sheet stock. Both an electric air furnace (circulating or still) and bath are needed. Depending upon the alloy, the heat-treating temperature range is 920° to 950° Fahrenheit (F). For convenient handling, rivets are heated in a tray or wire basket. They are quenched in cold water (70° F.) immediately after heat-treatment.

The 2017 and 2024-T4 rivets, which are heat-treatable, begin to age-harden within a few minutes after they are exposed to room temperature. Therefore, they must be used immediately after quenching or must be placed in cold storage. The most common method used for storing heat-treatable rivets at low temperature (below 32° F.) is an electric refrigerator. These rivets are referred to as "icebox" rivets. They

TABLE 1-4
RIVET IDENTIFICATION TABLE

MS20426
MS20427
100-DEGREE
COUNTERSUNK
HEAD





MS20470
MS20613
MS20615
UNIVERSAL
HEAD

MATERIAL	HEAD MARKING	MS MATERIAL CODE	MS20426 CSK HEAD	MS20427 CSK HEAD	MS20470 UNIV HEAD	MS20613 UNIV HEAD	MS20615 UNIV HEAD	HEAT TREAT BEFORE USING	STRENGTH PSI	
									SHEAR	BEARING
1100	PLAIN ○	A	X		X			NO	10000	35000
2117	DIMPLED ⊙	AD	X		X			NO	30000	100000
2017	RAISED TEAT ⊙	D	X		X			YES	34000	113000
2024	RAISED DOUBLE DASH ⊙	DD	X		X			YES	41000	136000
5056	RAISED CROSS ⊕	B	X		X			NO	27000	90000
CARBON STEEL	RECESSED TRIANGLE △			X		X		NO	35000	90000
CORROSION RESISTANT STEEL	PLAIN ○	F		X		X		NO	75000	90000
MONEL, FEDERAL SPECIFICATION QQ-N-281	RECESSED DOUBLE DIMPLE ⊙⊙	M		X			X	NO	55000	
COPPER, FEDERAL SPECIFICATION QQ-W-341	PLAIN ○	CU		X			X	NO	25000	

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NOTES:

1. THE PREDOMINATING COLOR OF LABELS FOR BOXES OF MS RIVETS ARE AS FOLLOWS: (MILITARY SPECIFICATION, MIL-R-5674) 1100-WHITE; 2017-YELLOW; 2117-ORANGE; 5056-BLUE.
2. ALL STRENGTH CALCULATIONS FOR RIVETS SHOULD BE BASED ON DIAMETER OF RIVET.
3. RIVET SPECIFICATION MIL-R-5674, COVERS MATERIALS TYPES A, AD, B D, AND DD LISTED ABOVE. ALL ALUMINUM ALLOY RIVETS ARE ANODIZED.
4. AN EXAMPLE RIVET NUMBER CODE IS AS FOLLOWS:

MS 20470 AD 5 12 P

- MS — MILITARY STANDARD
- 20470 — HEAD STYLE
- AD — MATERIAL CODE
- 5 — DIAMETER IN ONE THIRTY-SECONDS OF AN INCH
- 12 — LENGTH IN ONE-SIXTEENTHS OF AN INCH
- P — CADMIUM PLATED (STEEL RIVET)

can be stored under this condition for a 24-hour period. Any rivet not used within this time period must be removed and reheat-treated prior to use.

Icebox rivets attain about one half of their maximum strength in approximately 1 hour after driving and full strength in about 4 days. When 2017-T4 and 2024-T4 rivets are exposed to room temperature for 20 minutes or more, they must be reheat-treated. Once an icebox rivet has been taken from the refrigerator, it should not be mixed with the rivets still in cold storage. If more rivets are removed from the icebox than can be used in 20 minutes, they should be placed in a separate container and stored for reheat-treating. Heat treatment of rivert may be repeated a number of times if done properly. Proper heating times and temperatures are as follows:

Heating Time—Still Air Furnace

Rivet Alloy	*Time at Temperature*	*Heat-Treating Temperature*
2024-T4	1 hour	920°F + 10° F.
2017-T4	1 hour	940°F + 10° F.

Heating Time—Circulating Air Furnace

Rivet Alloy	*Time at Temperature*	*Heat-Treating Temperature*
2024-T4	30 minutes	920°F + 10° F.
2017-T4	30 minutes	940°F + 10° F.

Heating Time—Salt Bath

Rivet Alloy	*Time at Temperature*	*Heat-Treating Temperature*
2024-T4	30 minutes	920°F + 10° F.
2017-T4	30 minutes	940°F + 10° F.

Reheating an excessive number of times will result in a gradual hardening of the rivet. Fifteen or more times is considered excessive. Rivets which have been anodically oxide coated should not be reheat-treated in direct contact with molten salts more than five times.

The head markings will identify the composition of a rivet, whether it is heat-treatable or not. If the markings are not distinct, the hardness of the rivet can be determined by using the Rockwell hardness test.

Exercises (408):

1. What factor determines the heating temperature required when heat-treating icebox rivets?

2. The length of time icebox rivets are held at a specific temperature is directly related to what factor?

3. How long can icebox rivets be held in cold storage before they must be reheat-treated prior to use?

4. What is the maximum time icebox rivets can be exposed to room temperature before they must be reheat-treated?

5. What is the purpose of placing icebox rivets in cold storage?

409. Select the proper equipment required for pneumatic riveting in specific circumstances.

Earlier, we have stressed the importance of being able to skillfully use drilling tools and equipment. Just as important, is your ability to use the tools and equipment for pneumatic riveting. One mistake when riveting will ruin hours of work in preparing

Figure 1-20. Types of pneumatic riveters.

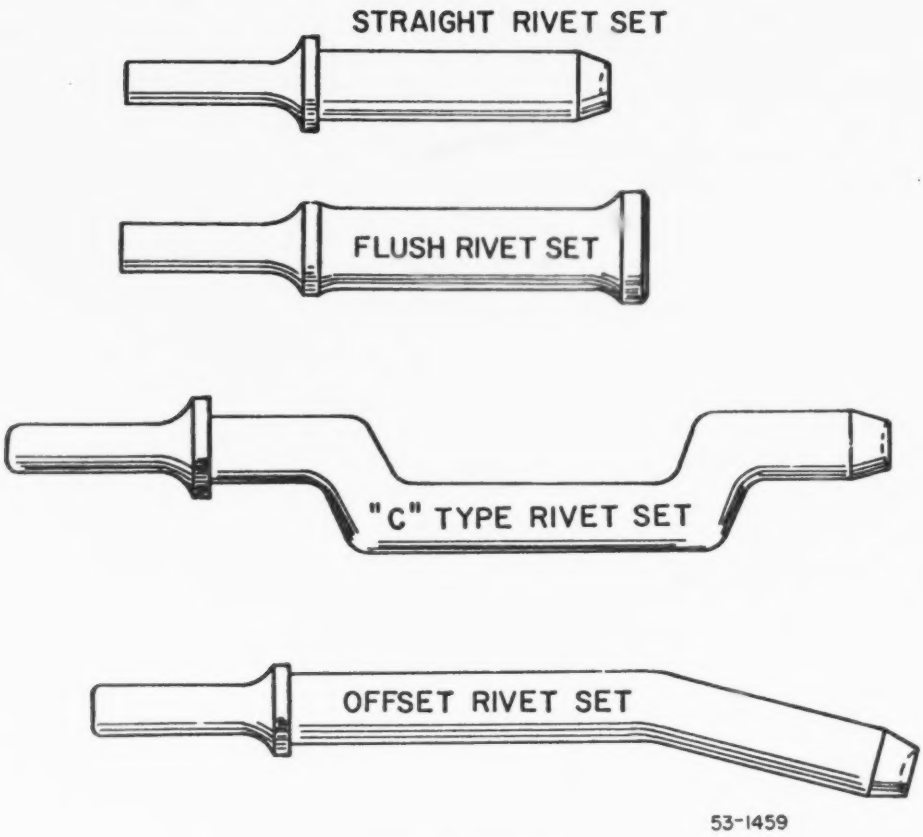


Figure 1-21. Rivet sets.

repair or replacement parts. Tools and equipment needed in the installation of rivets are discussed in the following paragraphs.

Pneumatic Riveters. The most common upsetting tool used in airframe repair work is the slow-hitting pneumatic hammer called a rivet gun. Pneumatic guns, or riveters, are available in various sizes and shapes. Figure 1-20 is a drawing of these shapes. The capacity of each gun, as recommended by the manufacturer, is usually stamped on the barrel. Pneumatic guns operate on air pressure of 90 to 100 pounds per square inch.

Pneumatic guns are used in conjunction with interchangeable rivet sets. Each set is designed to fit the type of rivet and location of the work. The shank of the set is designed to fit into the rivet gun. In figure 1-21 you can see that the force to buck the rivet is supplied by the air-driven hammer inside the barrel of the gun. The sets are made of high-grade carbon-tool steel and are heat-treated to give them strength and the ability to withstand wear.

Some of the precautions you need to observe when using a rivet gun are:

- Never point the gun at anybody at any time. It is a rivet gun (not a 0.45) and meant to be used for only one purpose—to drive or install rivets.
- Never depress the trigger mechanism unless the set is held tightly against a block of wood or a rivet.
- Never use the rivet gun as a toy. It is not a plaything but a tool to use in the right way to perform a job.
- Always disconnect the air hose from the rivet gun when it will not be in use for any appreciable length of time.

Sometimes it is necessary for you to use the squeeze method of riveting. This method has limited use, however, since it can be employed only over the edges of sheets or assemblies where conditions permit and where the reach of the squeeze riveter is deep enough.

Rivet squeezers are of three types: (1) hand, (2) pneumatic, and (3) pneudraulic. Basically they are alike, except that with the hand rivet squeezer compression is supplied by hand pressure; with the pneumatic rivet squeezer, by air pressure; and with the pneudraulic, by a combination of air and hydraulic pressure. One jaw is stationary and serves as a bucking bar; the other jaw is movable and does the upsetting. Riveting with a squeezer is a quick method and requires only one operator.

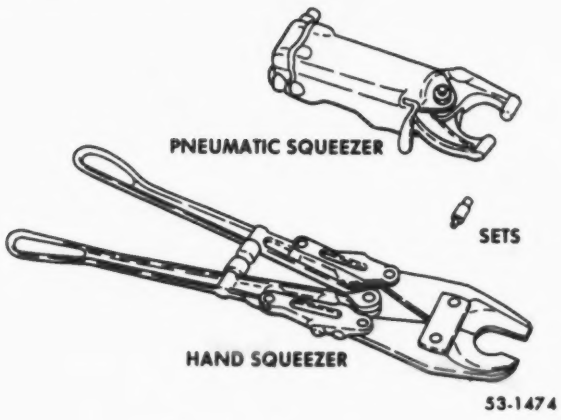


Figure 1-22. Squeeze riveters.

Squeeze riveters are usually equipped with either a C yoke or an alligator yoke. Yokes are available in various sizes to accommodate any size of rivet. The working capacity of a yoke is measured by its gap and its reach. The "gap" is the distance between the movable jaw and the stationary jaw; the "reach" is the inside length of the throat measured from the center of the end sets. Figure 1-22 illustrates two types of squeeze riveters.

End sets for squeeze riveters serve the same purpose as do rivet sets for pneumatic rivet guns and are available with the same type of heads. They are interchangeable to suit any type of rivet head. One part of each set is inserted into the stationary jaw, while the other part is placed in the movable jaws. The manufactured head end set is placed on the stationary jaw whenever possible. However, during some operations, it may be necessary to reverse the end sets, by placing the manufactured head end set on the movable jaw.

Before you use the pneumatic riveter, drop one or two drops of oil in the air inlet. This is the only way to get oil to all moving parts. Set the regulator adjustment screw to the position for proper operation of the riveter. Select the rivet set for the job and install the set in the barrel of the riveter.

Bucking Bars. A bucking bar is a tool which is held against the shank end of a rivet while the shop head is being formed. Most bucking bars are made of alloy bar stock, but those made of better grades of steel last longer and require less reconditioning. Bucking bars are made in a number of different shapes and sizes to facilitate rivet bucking in all places where rivets are used. Some of the various bucking bars are shown in figure 1-23.

The bars must be kept clean, smooth, and well polished. Their edges should be slightly rounded to prevent your marring the material surrounding the riveting operation. The face of the bar is usually concave to conform to the shape of the shop head to be made. The face should have a radius slightly larger than the thin head to insure solid bucking and to prevent marring the material to be riveted. Six pounds is the average weight of the bucking bars. These bars are sometimes called dollies, bucking irons, or bucking blocks.

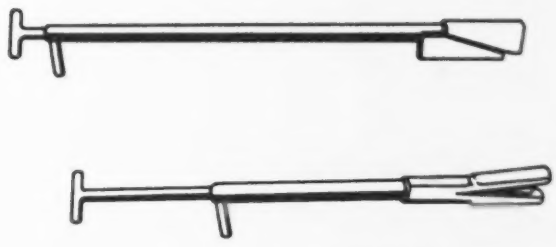
Inaccessible areas require special bars to accomplish the riveting operation. The expanding bucking bar, drawn in figure 1-24, is such a tool. It is a steel block whose diameter or width can be adjusted. It is attached to the end of a hollow steel shaft which contains a bar that can be twisted to expand or reduce the width of the block. It is used to buck rivets on the inside of tubular structures or in similar places that cannot be reached by regular bucking bars. The space must be small enough for one side of the partially expanded block to press against the tip of the rivet's shank and for the other side to press against a strong supporting surface. Expanding bucking bars speed up the process of riveting the skin on wing sections.

Hand Rivet and Draw Sets. A hand rivet set is a tool equipped with a die for driving a particular type rivet. Rivet sets are available to fit every size and shape of rivet head. The ordinary set is made of 1/2-inch carbon tool steel, about 6 inches long, and is knurled to prevent its slipping in your hand. Only the face of the set is hardened and polished.

Sets for roundhead and brazier-head rivets are recessed (or cupped) to fit the rivet head. In selecting the correct set, be sure that it will provide the proper clearance between the set and the side of the rivet head and between the surfaces of the metals and the set. Flush or flat sets are used for countersunk and flathead rivets. In order to seat flush rivets properly, be sure that flush sets are at least 1 inch in diameter.

Special draw sets are used to "draw up" the sheets in order to eliminate any opening between them

Figure 1-23. Buck bars.



53-1449

Figure 1-24. Expanding bucking bars.

before the rivet is bucked. Each draw set has a hole 1/32 inch larger than the diameter of the rivet shank for which it is made. Occasionally, the draw set and rivet header are incorporated into one tool. The header part consists of a hole sufficiently shallow, so that the set will expand the rivet and head it when struck with a hammer.

Rivet Cutters. In case you cannot obtain rivets of the required length, rivet cutters, shown in figure 1-25, can be used to cut rivets to the desired length. When using the rotary rivet cutter, insert the rivet in the correct hole, place the required number of shims (each shim is 1/16 of an inch) under the rivet head, and squeeze as you would a pair of pliers. Rotations of the discs will cut the rivet to give the right length (as determined by the number of shims inserted under the head). When using the large rivet cutter, place it in a vise, insert the rivet in the proper hole, and cut by pulling the handle, thus shearing off the rivet. If regular rivet cutters are not available, diagonal cutting pliers can be used as an emergency cutter.

Microshaver. Sometimes it is necessary for you to use a microshaver when making a repair involving the use of countersunk rivets. If the smoothness of the material (such as skin) requires that all countersunk rivets be driven within a specific tolerance, a microshaver is used. This tool has a cutter, a stop and two legs or stabilizers, as illustrated in figure 1-26.

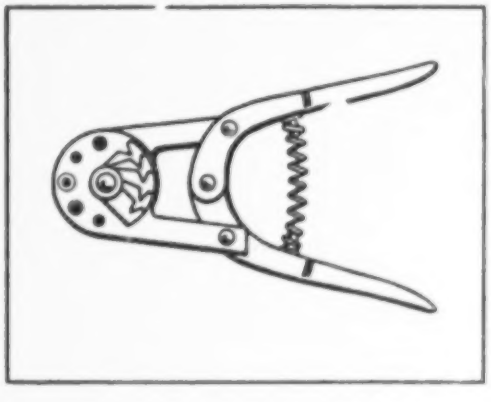
The cutting portion of the microshaver is located inside the stop. The depth of cut can be adjusted by pulling outward on the stop and turning it in either direction (clockwise for deeper cuts.) The marks on the stop permit adjustments of 0.001 inch.

If the microshaver is adjusted and held correctly, it will cut the head of a countersunk rivet to within 0.002 inch without damaging the surrounding material. When correctly adjusted, the shaver will leave a small round lot about the size of a pinhead on the microshaved rivet.

Exercises (409):

1. If you were going to install MS 20470-4-5 rivets, what is needed if you only have pneumatic gun and bucking bar?
2. What shape are the dies on a squeeze riveter when MS 20426 rivets are being installed?
3. What is the average weight of bucking bars?
4. If you were installing MS 20470-AD-4-4 rivets, what size draw set would you use?
5. Without the use of shims, a rivet cutter cuts rivets to 1/4 of an inch. How many shims would you use zmvcut MS 20470-AD-5-10 rivets to a required length of 3/8 of an inch?
6. If after installing a countersunk rivet, the head sticks up 0.010 above the surface, how much of the head can you remove, without damaging the surface?
7. To insure that countersunk rivets are seated properly, what size flush rivet set is recommended?

410. Clarify selected factors related to the methods used to install solid rivets.



53-1460

Figure 1-25. Rivet cutter.

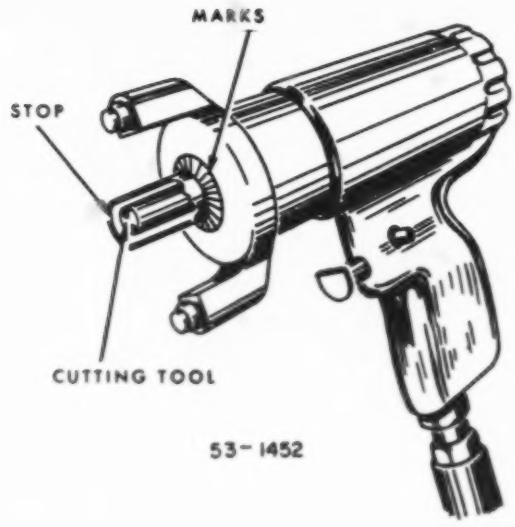


Figure 1-26. Microshaver.

All types of soild rivets are driven in, in basically the same manner. The chief difference lies in the sizes and weights of the guns and bucking bars used to drive the rivets. The methods of driving solid shank rivets are classified as one of two types, depending upon whether the riveting equipment is portable or stationary. Since stationary riveting equipment is seldom used in airframe repair work, only portable equipment, used in hand, pneumatic, and squeeze riveting methods, is discussed here.

Before driving any rivets, be sure that all holes line up perfectly, all shavings and burrs have been removed, and the parts to be riveted are fastened securely together.

Two men, a "gunner" and a "bucker," usually work as a team when installing rivets. However, on some jobs the riveter holds a bucking bar with one hand and operates a riveting gun with the other. When a team is riveting, an efficient signal system can be used to develop the necessary teamwork. The code usually consist of tapping the bucking bar against the work—one tap may mean "not fully seated, hit it again"; two taps may mean "good rivet"; and three taps may mean "bad rivet, remove and drive another," etc.

Bucking. Selection of the appropriate bucking bar is one of the most important factors in bucking rivets. If the bar does not have the correct shape, it will deform the rivet head. Again, if the bar is too light, it will not give the necessary bucking weight and the material may become bulged toward the shop head. Also, if the bar is too heavy, weight and the bucking force may cause the material to bulge away from the shop head. Weight of bucking bars range from a few ounces to 10 pounds, depending upon the nature of the work. Recommended weights of bucking bars to be used with various rivet sizes are given in table 1-5.

Always hold the face of the bucking bar at right angles to the rivet shank, as shown in figure 1-27. Failure to do this will cause the rivet shank to bend with the first blows of the rivet gun, and the material will become marred with the final blows. The bucker must hold the bucking bar in place until the rivet is completely driven. If the bucking bar is removed while the gun is in operation, the rivet set may be driven through the material. Do not bear down too heavily on the shank of the rivet. Allow the weight of the bucking bar to do most of the work while your hands merely guide the bar and supply the necessary tension and rebound action.

Allow the bucking bar to vibrate in unison with the gun set. This process is called coordinated bucking. Coordinated bucking can be developed through pressure and stiffness applied at the wrists; with experience, a high degree of deftness can be obtained. Should you fail to vibrate the bar at gun-set speed, you will cause the material to kink into a depression.

Lack of proper vibrating action, the use of a bucking bar that is too light or too heavy, and/or failure to hold the bucking bar at right angles to the rivet can all cause defective rivet heads. A rivet going "clubhead" (malforming) can be corrected by rapidly moving the bucking bar across the rivet head in a direction of clubhead travel. This corrective action can be accomplished only while the gun is in action and the rivet is partly driven. If a rivet shank bends at the beginning of the bucking operation, place the bar in the corrective position only long enough to straighten the shank.

Hand Driving. Under certain conditions, you may have to do all your aircraft riveting by hand driving. You can use either of two methods of hand riveting, depending upon the location and accessibility of the work. In one method, you drive from the manufactured head end of the rivet with a handset and hammer, and buck the shank end with a suitable bucking bar, as shown in figure 1-28. In the other

TABLE 1-5
RECOMMENDED BUCKING BAR WEIGHTS

RIVET DIAMETER (IN INCHES)	APPROX. WEIGHT (IN POUNDS)
3/32	2 to 3
1/8	3 to 4
5/32	3 to 4 1/2
3/16	4 to 5
1/4	5 to 6 1/2

53-1450

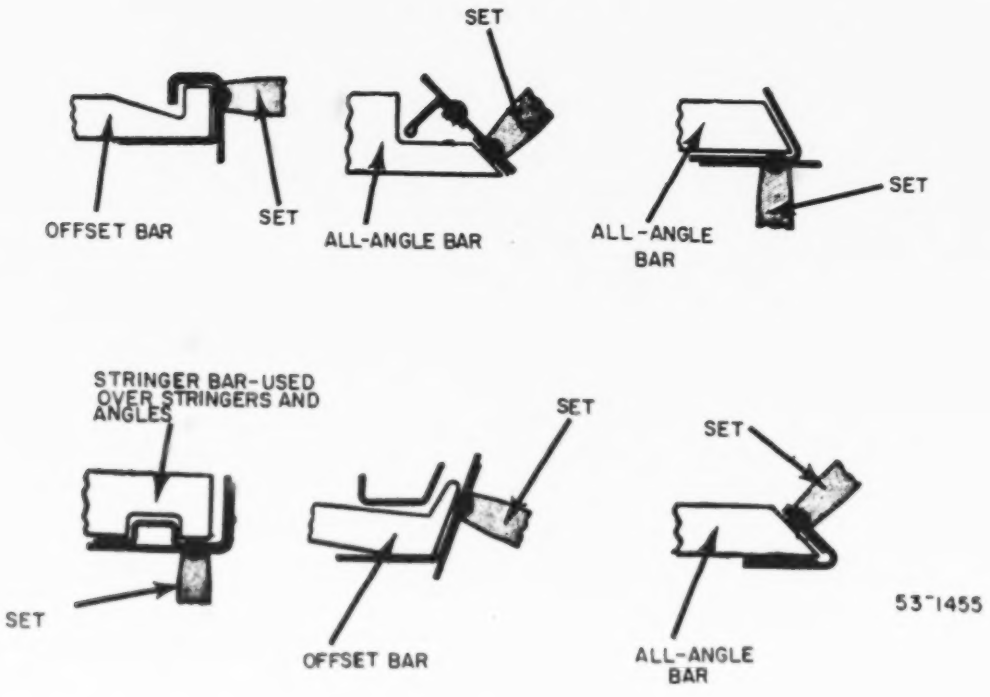


Figure 1-27. Correct use of bucking bars.

method, you drive from the shank end of the rivet with a handset and a hammer, and buck the manufactured head with a handset held in a vise or a bottle bar (a special bucking bar recessed to hold a rivet set). This latter method is known as reverse riveting. It is commonly used in hand riveting but is not considered good practice in pneumatic riveting.

When using either of the described methods, keep hammer strokes to a minimum. Too much hammering will change the crystaline structure of the rivet or the material around it, causing the joint to lose some of its strength. Hold the bucking bar and rivet set square with the rivet at all times. Misuse of the rivet set and bucking bar will result in marring or scratching the rivet head or material, and may cause undue corrosion. This, in turn, will weaken the structure of the aircraft.

Pneumatic Drilling. The procedure for pneumatic riveting is practically the same as that for hand riveting. Preparation of the sheet, selection of rivets, and drilling of rivet holes are the same. In hand riveting, however, you apply the pressure for bucking the rivet by using a handset and hammer. In pneumatic riveting, you apply the pressure with a set and an air-driven hammer or gun.

To get good riveting results with a pneumatic rivet gun, follow these basic pointers:

(1) Select the right type and size of rivet gun and the correct rivet set for the size of rivet to be driven.

(2) Install the rivet set firmly, as shown in example 1 of figure 1-29.

(3) Adjust the speed of gun (vibrations per minute, vpm), as shown in example 2 of figure 1-29.

CAUTION: Always press set firmly against a block of wood before pressing the trigger. Never operate the gun without resistance against the set, because the vibrating action may cause the retaining spring to break, allowing the gun set to fly out of the gun. Also, free vibration may flare or mushroom the gun end of the set, causing it to bind in the barrel of the gun.

(4) When operating the rivet gun, hold the gun with one hand and the rivet set with the other. (See example 3, figure 1-29).

(5) Hold the rivet set at right angles to work to prevent damage to the rivet head or the surrounding material (example 4 of figure 1-29).

(6) Hold the gun and set tightly against the rivet head and do not remove them until you have removed your finger from the trigger (example 5 of figure 1-29).

(7) Upset the rivet with one medium blast (example 6 of figure 1-29).

(8) Remove the bucking bar and check the shop head of the rivet. It should be 1½ times the diameter of the rivet in width and 1/2 times the rivet diameter in height.

(9) If the rivet needs further driving, repeat the necessary procedures to complete the job.

A small piece of adhesive tape applied to the cupped end of the rivet set often corrects an unsatisfactory cupped condition, which occasionally gives trouble in forming uniformly shaped rivet heads.

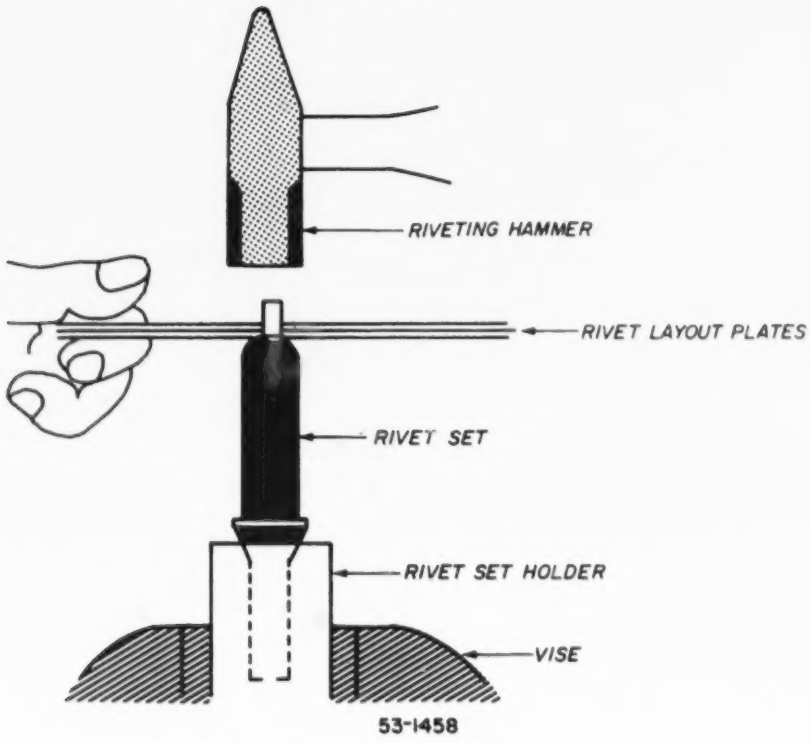


Figure 1-28. Hand riveting procedures.

Squeeze Riveting. The squeezer method of driving a rivet produces the most uniform and balanced type of shop head. Here (1) each rivet is upset in a single operation, (2) all rivets are headed over with uniform pressure, (3) all heads are formed alike, and (4) each rivet shank is sufficiently and uniformly expanded to completely fill each rivet hole. Squeeze riveters come equipped with pairs of end sets, each pair being designed for a particular job. Once you have selected the correct end set and adjusted the squeezer for a particular application, all rivets will be driven uniformly, thus providing an efficient method of riveting.

Portable squeezers are particularly suited for riveting large assemblies in situations where the tool must be moved in relation to the work. They are not too heavy and can be operated by one person easily. The preparation of the material for riveting with the squeeze riveter is the same as that for hand or pneumatic riveting. For better results when using the squeeze riveter, observe these rules:

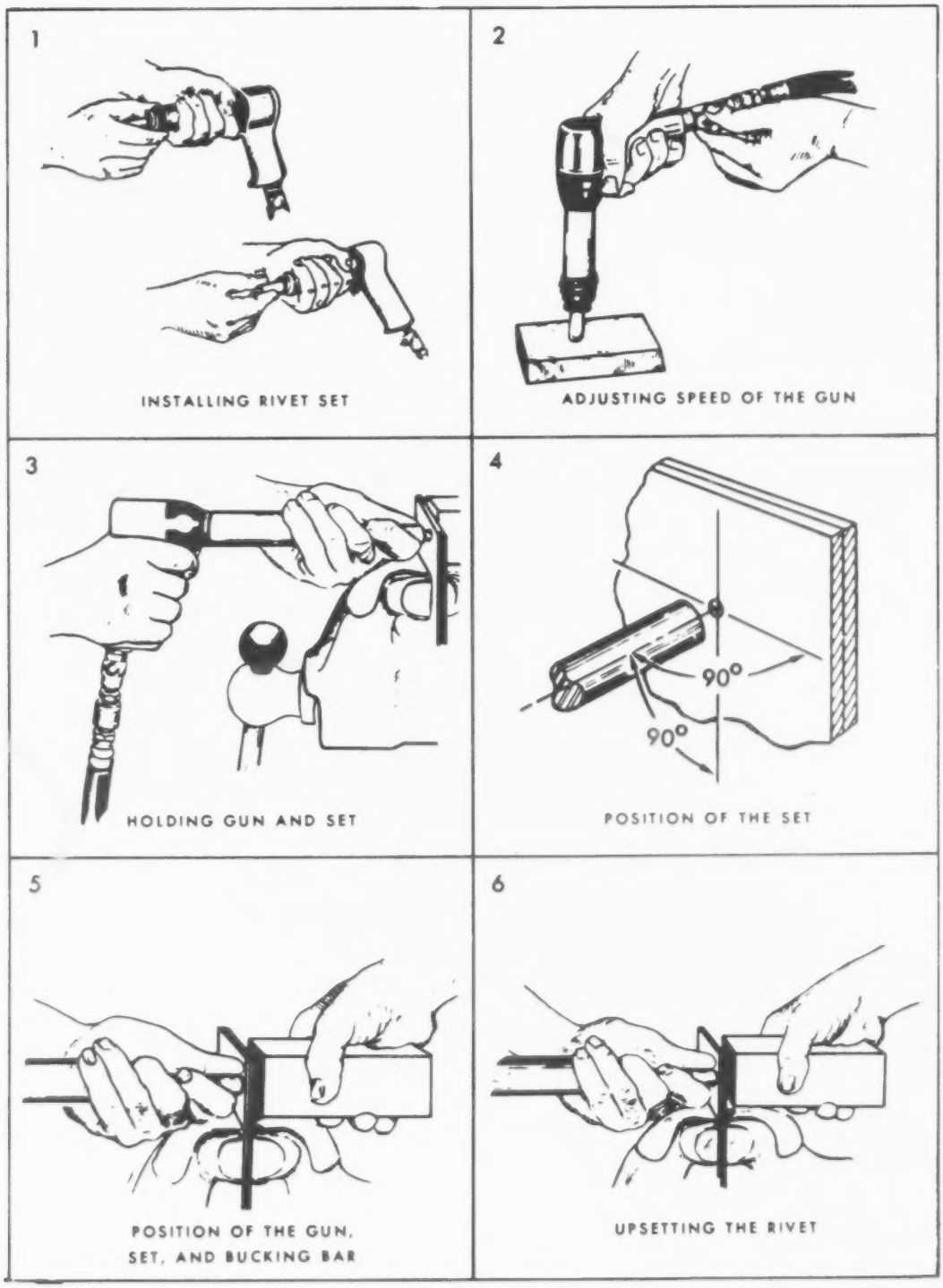
(1) Carefully select and insert suitable end sets to match the rivet being used. The importance of using the right end sets cannot be overemphasized. It is impossible to buck the rivet properly unless the correct pairs are used. Always be sure that the air is shut off or the squeezer is disconnected when inserting end sets.

(2) Adjust the squeezer cylinder pressure so that you obtain the correct pressure for the diameter of the rivet being used. Most squeezers are equipped with a blow-off valve to regulate the cylinder pressure. This unit governs the amount of air pressure allowed in the cylinder.

(3) Carefully regulate the gap to conform to the length of the rivet being used. Some squeezers are equipped with a gap regulator which controls the stroke of the plunger of a C yoke squeezer, or the movement of the movable jaw of an alligator yoke squeezer. For squeezers not equipped with a gap regulator, the gap can be adjusted by placing metal shims under the end sets of both jaws, or by using end sets of different lengths. On some types of squeeze riveters, the end set on the stationary jaw is held in place by an Allen screw, which can be adjusted to regulate the gap.

(4) Before using the squeezer on the work, test the cylinder pressure and gap for accuracy of adjustment on a piece of scrap material. The scrap material must be the same thickness as the material being used, and the rivets, the same length and diameter.

(5) If the parts to be riveted are small and easily handled, mount the squeeze riveter in a bench vise or in a special clamp, and hold the part to be riveted in your hand.



53-1451

Figure 1-29. Pneumatic riveting procedures.

Exercises (410):

1. What is meant by "coordinated bucking"?

2. What is the recommended weight of the bucking bar required to install MS 20424-AD-3-4 rivet?

3. Define the riveting term "reverse riveting."

4. When is the bucking bar removed from the rivet being installed?

5. What are the dimensions of a properly formed shop head?

6. How can you adjust the gap clearance on squeeze riveter without a gap regulator?

7. The pressure setting if a squeeze riveter is based on what physical feature of the rivet being installed?

8. What causes crystalline structure changes within a rivet when installing it?

9. Why would you place a small piece of adhesive tape on the cupped end of the rivet set?

10. What results when the bucking bar is not heavy enough for the rivet being installed?

411. Specify the types of rivet failures and cite causes of each type.

Generally speaking, the design of riveted joints is based on the theory that the total joint strength is simply the sum of the individual strengths of a whole group of rivets. It is then obvious that, if any one rivet fails, its load must immediately be carried by others of the group. If they are unable to carry this added load, progressive joint failure then occurs. Stress concentrations will usually cause one rivet to fail first; however, careful analysis of such a rivet in a joint will indicate that it has been too highly loaded, the possibility being that neighboring rivets may have partially failed.

Shear Failure. Shear failure is perhaps the most common of rivet failures. It is simply a breakdown of the rivet shank by forces acting along the plane of two adjacent sheets, causing a slipping action which may be severe enough to cut the rivet shank in two. If the shank becomes loaded beyond the yield point of the material and remains overloaded, a permanent shift is established in the sheets, and the rivet shank may become joggled.

Bearing Failure. If the rivet is excessively strong in shear, bearing failure occurs in the sheet at the edge of the rivet hole. The application of large rivets in thin sheets brings about such a failure. In that case, the sheet is locally crushed or buckled, and the buckling destroys the rigidity of the joint. Vibrations, set up by engine operation or by air currents in flight, may cause the buckled portion to flutter and the material to break off close to the rivet head. If buckling occurs at the end of the sheet, a tearout may result. In either case, replacement of the sheet is necessary.

Head Failure. Head failure may result from complex loadings occurring at a joint, causing stresses of tension to be applied to the rivet head. The head may fail by shearing through the area corresponding to the rivet shank or, in thicker sheets, may fail through a prying action which causes failure of the head itself. Any visible distortion is cause for replacement. This latter type of head failure is especially common in blind rivets.

Exercises (411):

1. What are the types of rivet failures?

2. When is bearing failure most likely to occur?

3. An increase of what structural stress usually results in rivet head failure?

4. What happens to the remaining rivets in a joint after one has failed?

5. What type of rivet failure is especially common in blind rivets?

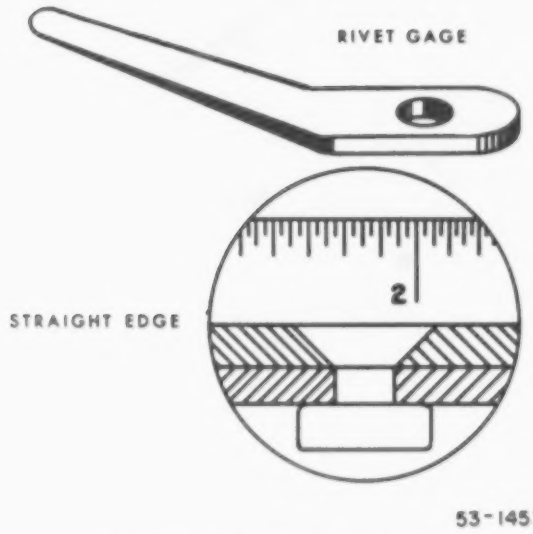


Figure 1-30. Tools used to gage rivets.

412. Identify in detail the procedures used to inspect and remove solid rivets.

Inspection of Rivets. In order to obtain high structural efficiency in the manufacture and repair of aircraft, an inspection must be made of all rivets before the part is put in service. This inspection consists of examining both the shop and manufactured heads and the surrounding skin and structural parts for deformities. A scale of rivet gage can be used to check the condition of the upset rivet head to see that it conforms to the proper requirements. Deformities in the manufacturer's head may be detected by the trained eye alone. However, on flush rivets, you may use a straightedge, as shown in figure 1-30.

Some common causes of unsatisfactory riveting are improper bucking, rivet set slipping off or being held at the wrong angle, and rivet holes or rivets of the wrong size, as seen in figure 1-31. Countersunk rivets not flush with the well, work not properly fastened together during riveting, the presence of burrs, rivets too hard, too much or too little driving, and rivets out of line are also causes.

Occasionally, during the repair of an aircraft structural part, it is wise to examine adjacent parts to determine the true condition of neighboring rivets. In doing so, you may have to remove the paint. The presence of chipped or cracked paint around the heads may indicate shifted or loose rivets. Look for tipped or loose rivet heads. If the heads are tipped or if rivets are loose, they will show up in groups of several consecutive rivets and will probably be tipped in the same direction. If heads which appear to be tipped are not in groups and are not tipped in the same direction, tipping may have occurred during some previous installation.

Inspect rivets which you know have been critically loaded but which show no visible distortion by drilling off the head and carefully punching out the shank. Upon examination, if the shank appears joggled and the holes in the sheet seem misaligned to you, the rivet has failed in shear. In that case, try to determine what is causing the shearing stress and take the necessary corrective action. Flush rivets that show head slippage within the countersink or dimple, indicating either sheet bearing failure or rivet shear failure, must be removed for inspection and probable replacement.

Joggles in removed rivet shanks indicate partial shear failure. Replace these rivets with the next larger size. Also, if the rivet holes show elongation, replace the rivets with the next larger size. Sheet failures (such as tearouts, cracks between rivets, and the like) usually indicate damaged rivets, and the complete repair of the joint may require replacement of the rivets with the next larger size.

The general practice of replacing a rivet with the next larger size (1/32 inch greater diameter) is necessary to obtain the proper joint stregth of rivet and sheet when the original rivet hole is enlarged. If the rivet in an elongated hole is replaced by a rivet of the same size, its ability to carry its share of the shear load is impaired and joint weakness results.

Removing Rivets. When removing a rivet for replacement, be very careful, so that the rivet hole will retain its original size and shape and replacement with larger size rivet will not be necessary. If the rivet is not removed properly, the strength of the joint may be weakened and the replacement of rivets made more difficult. Refer to figure 1-32, as the procedures for removing rivets are covered in the following paragraphs.

When removing a rivet, work on the manufactured head. It is more symmetrical about the shank than the shop head is, and there will be less chance of damaging the rivet hole or the material around it. To remove rivets, use handtools, a power drill, or a combination of both. The preferred method is to drill through the rivet head and drive out the remainder of the rivet with a drift punch. First, file a flat area on the head of any round- or brazier-head rivet, and center punch the flat surface for drilling. On thin metal, back up the rivet on the upset head when center punching to avoid depressing the metal. The dimple in 2117T rivets usually eliminates the necessity of filing and center-punching the rivet head.

Select a drill one size smaller than the rivet shank and drill out the rivet head. When using a power drill, set the drill on the rivet and rotate the chunk several revolutions by hand before turning on the power. This procedure helps the drill cut a good starting spot. It also eliminates the chance of the drill slipping off and tracking across the metal. Drill the rivet to the depth of its head, while holding the drill at a 90° angle. Be careful not to drill too deep, since

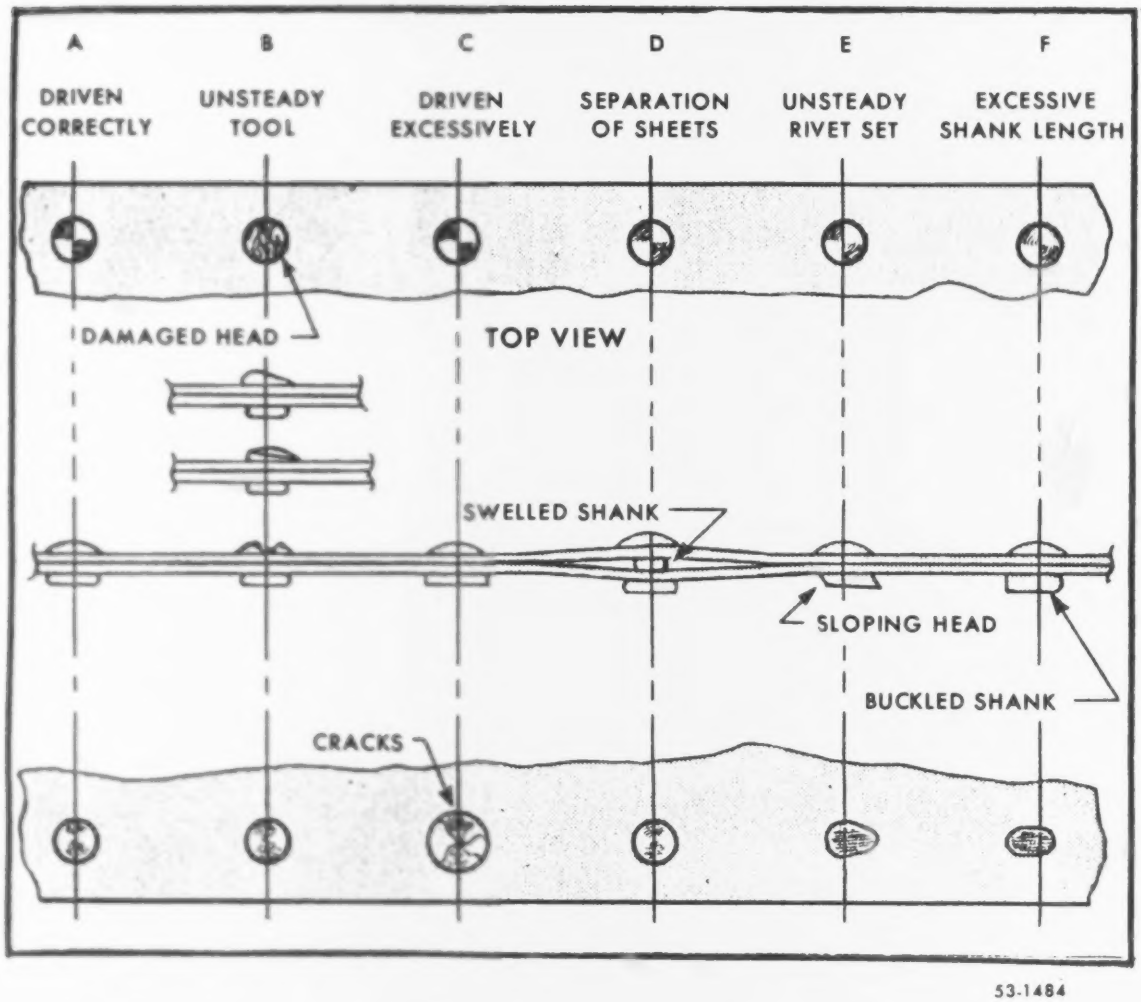


Figure 1-31. Rivet inspection standard.

the rivet shank will turn with the drill and cause a tear. The rivet head will often break away and climb the drill, which is a good signal to withdraw the drill. If the rivet head does not come loose of its own accord, insert a drift punch into the hole and twist slightly to either side until the head comes off.

Drive out the shank of the rivet with a drift punch slightly smaller than the diameter of the shank. On thin metal or unsupported structures, support the sheet with a bucking bar while driving out the shank. If the shank is exceptionally tight after the rivet head is removed, drill the rivet about two-thirds of the way through the thickness of the material and then drive out the remainder of the rivet with a drift punch.

The procedure for the removal of flush rivets is the same as that described here, except that no filing is necessary. Be very careful to avoid elongation of the dimpled or the countersunk holes. The rivet head should be drilled to appriximately one-half the thickness of the top sheet.

Exercises (412):

1. What is a rivet gage used for when inspecting installed rivets?

2. When inspecting the manufactured head of flush rivets, why would you use a straightedge?

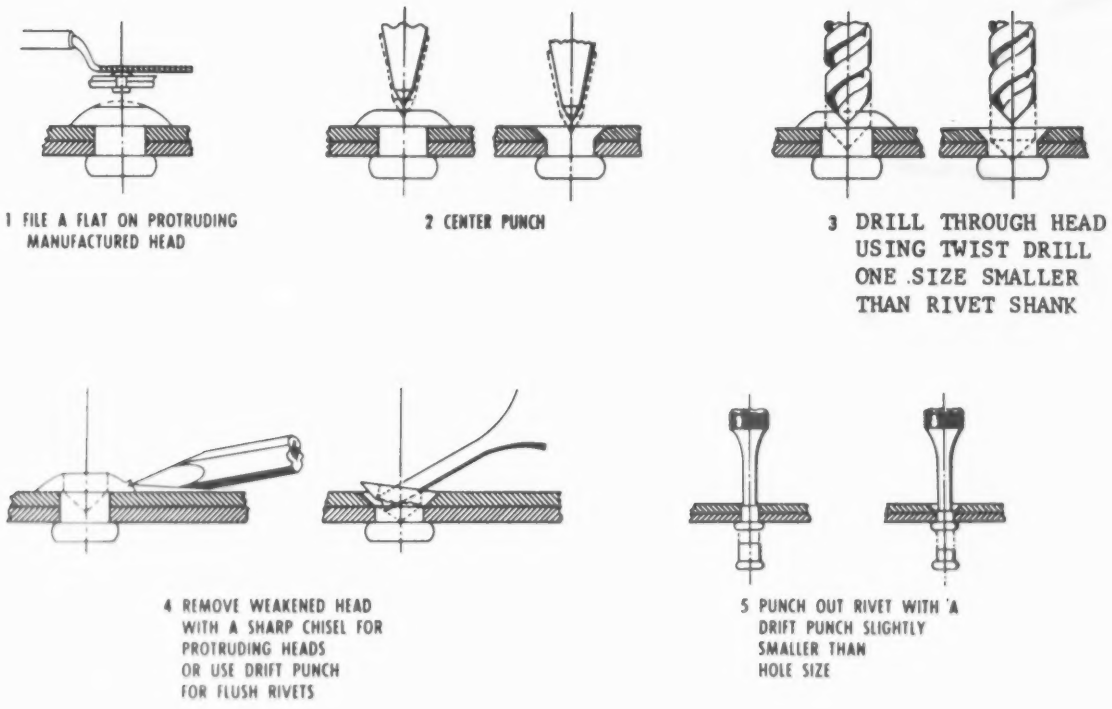

1 FILE A FLAT ON PROTRUDING MANUFACTURED HEAD
2 CENTER PUNCH
3 DRILL THROUGH HEAD USING TWIST DRILL ONE SIZE SMALLER THAN RIVET SHANK
4 REMOVE WEAKENED HEAD WITH A SHARP CHISEL FOR PROTRUDING HEADS OR USE DRIFT PUNCH FOR FLUSH RIVETS
5 PUNCH OUT RIVET WITH A DRIFT PUNCH SLIGHTLY SMALLER THAN HOLE SIZE

Figure 1-32. Rivet removal techniques.

3. What may be indicated by the presence of chipped or cracked paint around the heads of rivets?

4. Why would you remove rivets which show no visible distortion?

5. Why should you be extra careful when removing rivets?

6. Why is it recommended that you work from the manufactured head when removing rivets?

7. What size should the drill be when drilling out rivets?

8. How far down into the head of the countersunk rivet should you drill for removal purpose?

9. What must you do when punching out rivet shanks in thin material?

10. Why isn't it necessary to center punch MS 20470-AD-4-5 rivets prior to drilling off the rivet head?

CHAPTER 2

Step I, Pre-Repair Procedures

IN MAKING ANY REPAIR, a logical sequence of steps must be followed. This not only saves time and material, it also insures that *all* factors are considered, so that none will be overlooked. This is what quality workmanship is all about.

This chapter and the remaining chapters are designed to follow the sequence of a repair situation—from start to finish. No matter how simple or complex a repair may be, you must have a "plan of attack" in accomplishing the repair. As we proceed from step to step, factors will be included that influence that step, such as tools and repair techniques.

2-1. Inspection Techniques

The first and one of the most important steps in repairing a structural damage is "sizing up" the job and making an accurate estimate of what is to be done.

This sizing up includes an estimate of the best type and shape of patch to use; the type, size, and number of rivets needed; and the strength, thickness, and kind of material required to make the repaired member no heavier (or only slightly heavier) and just as strong as the original. You also inspect the surrounding members for evidence of corrosion and load damage, so that you can estimate accurately the required work that needs to be accomplished. Inspection of the damaged area is the starting point in sizing up a job.

413. State each critical factor to look for when evaluating areas for damages.

When you visually inspect the damage, remember that there may be other kinds of damage than those caused by flying missiles from the exterior, such as flak. A rough landing may overload one of the landing gear, for example, causing it to become sprung. During inspection and sizing up of the repair job consider how far the damage caused by the sprung shock strut extends in to supporting struc-members. A shock occurring at one end of a member is transmitted throughout its length; therefore, inspect all rivets, bolts, and attaching structures along the complete member for evidence of damage.

The following paragraphs describe critical factors to examine in making a detailed visual inspection for damage.

Critical Points. For damage occurring on doors, inspect such critical points as hinges for misalignment, cracks, and broken or missing tangs. Inspect door latches for proper rigging, binding, and deformed or broken hooks. Inspect door fasteners and holes for deformation and elongation. On damaged skin panels, inspect supporting structure for cracks and deformation. Inspect landing gear support structure for cracks, deformation, and misalignment.

Fasteners. Thoroughly inspect riveted and bolted joints in damaged area for loose, sheared, or tilted heads. If the head of a bolt is tilted or loose, remove the bolt and inspect for deformation of bolt and elongation of the hole. Inspect the complete row or pattern of fasteners. On painted surfaces you can detect rivet tilt by looking for cracks in the paint around the rivet.

Cracks, Dents, and Gouges. Inspect for dents which appear as hollows or depression in the skins and panels. Dents can also be detected by shadowing affects on the skins. Gouges will appear as scraped areas on painted and/or unpainted surfaces where metal is removed. Cracks in forgings, castings, and extrusions can also usually be detected visually, but suspected areas should be fluorescent penetrant inspected.

Delamination and Voids. Visually inspect boron epoxy composite, aluminum, titanium, and fiberglass honeycomb sandwich assemblies for delamination and voids. Delamination and voids can be easily detected by tapping the suspected area lightly with a coin. Damaged areas will give a dull lifeless sound, while undamaged areas will give off a metallic ringing sound. Delamination caused by impact damage will appear as white or light colored areas and may be loose along the edges of laminations.

Corrosion. Inspect the inside surface of skin panels and supporting structure. Inspect pockets and corners where moisture may accumulate. Corrosion can be recognized by white deposits of spots. In some cases, corrosion can be detected by dulling, and in severe cases, by pitting or blistering of the metal.

Exercises (413):

1. If damage occurs on an access door, what should you look for when inspecting the hinge area?

2. What possible damage is indicated by a bolt being tilted or loose when inspecting a damaged part?

3. How should forgings, castings, and extrusions be inspected when checking for cracks?

4. What simple method is used to inspect for delaminations and voids in honeycomb sections?

5. What areas of a part should you inspect for corrosion?

414. Given detailed descriptions of damaged areas, determine the proper classification of the stated damage.

Damages that you find during your inspection are grouped into four general classes, as shown in figure 2-1. The availability or lack of repair materials and time are the most important factors in determining whether a part is repaired or replaced. The classes and a general description of each type damage are discussed in the following paragraphs.

Negligible Damage. A damage which does not affect the structural integrity of the member involved, or a damage which can be corrected by a simple procedure without placing flight restrictions on the aircraft, is classified as "negligible damage." Small dents, scratches, cracks, or holes that can be repaired by smoothing, sanding, stop drilling, or hammering out, or otherwise repaired without the use of additional materials, fall in this classification.

Damage Repairable by Patching. A damage classified as "damage repairable by patching" is any damage exceeding negligible damage limits which can be repaired by bridging the damaged area of component with a splice material. The splice or patch material used in internal or riveted and bolted repairs is normally of the same type of material as the damaged part, but one gage heavier. In a patch repair, filler plates of the same gage and type of material as that in the damaged component may be used for bearing purposes or to return the damaged part to its original contour.

Damage Repairable by Insertion. Any damage which can be repaired by cutting away the damaged section, replacing the removed portion with a like section of the damaged component and securing the insertion with splices at each end is classified as "damage repairable by insertion."

Damage Necessitating Replacement of Parts. Replacement of an entire part is considered when one or more of the following conditions exist:

- A complicated part has been extensively damaged.
- Surrounding structure or inaccessibility makes repair impractical.
- Damaged part is relatively easy to replace.
- Forged or cast fittings are damaged beyond the negligible limits.

Such damage is classified as "damage necessitating replacement of parts."

Exercises (414):

1. What is the classification of a damaged area requiring a flush skin repair?

2. Minor dents that can be hammered out are classified as what type of damage?

3. Into what classification can the replacement of a damaged section with a like section, secured in place with splices at each end, be placed?

4. What is the normal classification of a broken casting?

415. Differentiate between the methods used to classify types of repairs.

Types of Repairs. There are four types of repair: (1) permanent, (2) temporary, (3) one-time flight, and (4) combat. The type of repair made will depend upon the materials, tools, amount of time available and the maintenance level. Temporary and one-time flight repairs will generally be made only at organizational and flied maintenance when it is impractical to make a permanent repair.

Permanent Repair. A "permanent repair" makes the strength of the repaired structure equal to or greater than its original strength and also satisfies aerodynamic, thermal, and interchangeability requirements.

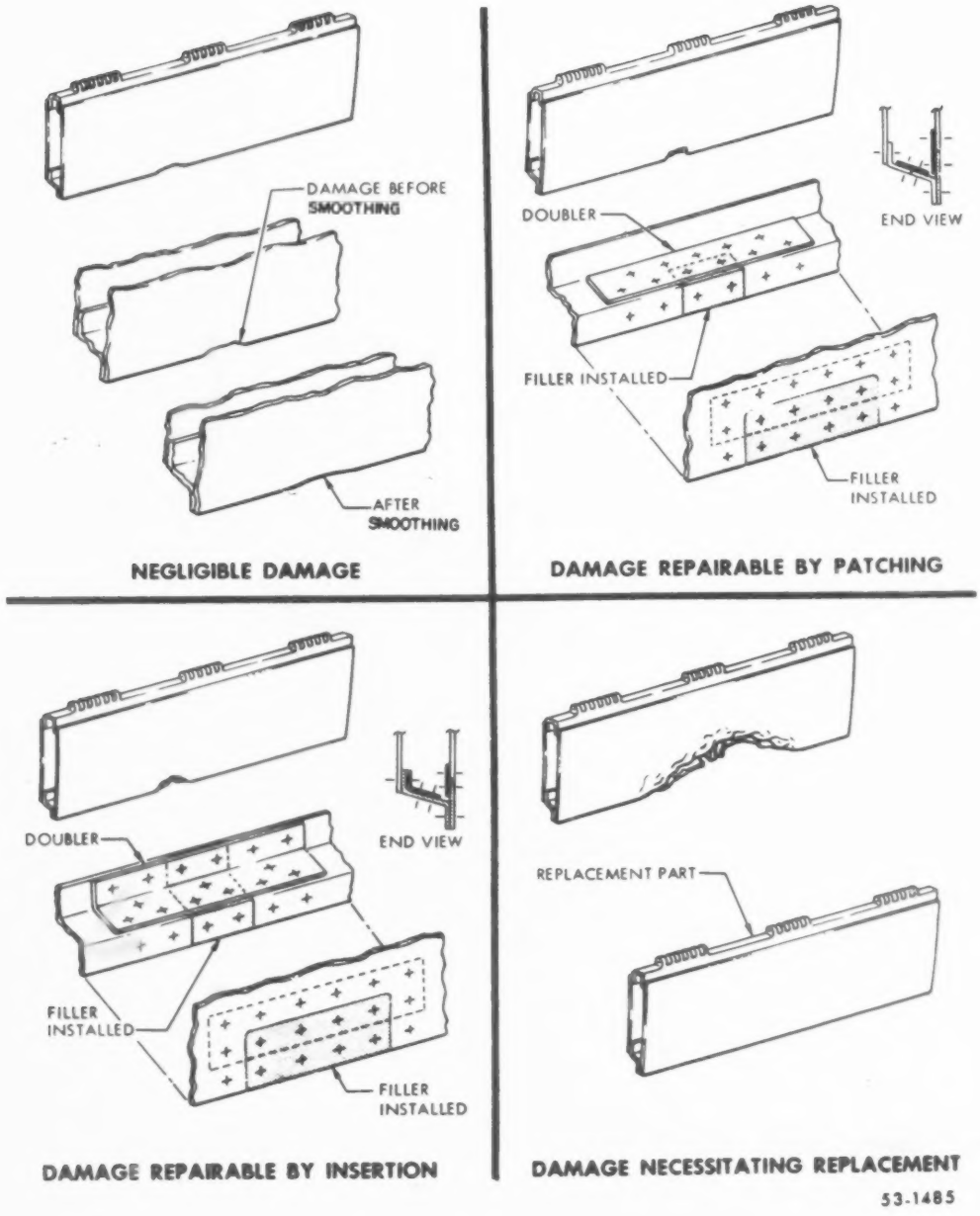


Figure 2-1. Classification of damage.

Temporary repair. "Temporary repairs" are repairs that return the aircraft to its original configuration structurally, but do not fully restore it aerodynamically. External patches, protruding head fasteners, etc., are temporary repairs and should be made according to the requirements of the -3 TO or according to the instructions of an aeronautical structures engineer. In spite of the undesirable effects of nonflush (temporary) repairs, they are sometimes necessary to make aircraft available for flight in the shortest possible time. They are temporary repairs, however, and they should be replaced with permanent (flush) repairs when possible, and as soon as possible, for aerodynamic smoothness. NOTE: Stop drilling is normally considered as temporary and a permanent repair should be accomplished at the earliest possible date.

One-time flight repair. A one-time flight repair restores a limited load-carrying capacity to the damaged structural member which allows the aircraft to be flown to a repair facility. One-time flight damaged repairs should be designed by an aeronautical structures engineer.

WARNING: When a one-time flight repair is made to an aircraft, the cockpit must be placarded to indicate flight restrictions of the aircraft.

Combat repair. This is a repair which can be used to quickly return battle-damaged aircraft to operational status.

Exercises (415):

1. What type of repair returns the aircraft to its original configuration structurally, but does not fully restore it aerodynamically?

2. When is it necessary to have an aeronautical structure engineer design a repair?

3. What type of repair restores the aircraft to its original configuration structurally and aerodynamically?

4. When events require the swift return of a battle-damaged aircraft to flight status, what type of repair is effected?

2-2. Researching Information

Once you have finished your inspection and classification of the damaged area, your next step is to determine the proper "fix" required. Technical orders provide you with the means of accomplishing the repair correctly. The TOs that you will use the most are the -3 series structural repair manuals and the 1-1A series of manuals.

416. Identify the particular locations of specific types of information normally contained in all -3 structural repair manuals by pages or sections.

A technical manual of structural repair instructions (-3) is issued for each aircraft and contains detailed repair information for that aircraft. Therefore, each -3 technical manual is used as a reference manual. Its purpose is to make it possible to restore the aircraft to active service within a minimum period of time and with a minimum of replacement parts. It includes instructions for determining the extent of damage and for repairing damages by patching, splicing, and other recommended methods. In addition, a definition of damages requiring replacement parts is included. The -3 is intended for use in the field, where major repair facilities may not be available. Information necessary to accomplish repair functions of the major repair depots is often included in it.

Typical Format. Most of the -3 technical manuals contain a title page, a list of revised pages issued, a table of contents, a list of illustrations, and an introduction.

Title page. The title page is the first printed page of the technical order. This page lists the technical order number, the technical manual title, the aircraft model and series to which it pertains, the date of publication and the latest date of revision, as shown in figure 2-2.

"A" page. The list of effective pages (the "A" page) follows the title page. It is a list of the latest revised pages added to the technical order to keep it up to date. These pages contain revisions which affect the repair procedure. Consequently, the technical order must be revised to keep pace with these changes. Revisions are printed on full-page form and issued periodically to replace the outdated pages of the original technical order. If a page has been revised, it is noted both at the bottom of the page in heavy print and also in the list of revised pages. The revised pages are listed in numerical order, with the latest effective date for the page appearing on the right side of the list. This can be seen in figure 2-3.

List of illustrations. The list of illustrations gives the figure number and page number of the illustration, as shown in figure 2-4. All illustrations are listed as they are shown in the text of each section—that is, all of the illustrations which pertain to the wing group are found in that section. The list of illustrations also contains the necessary information for locating station number diagrams, exploded views of the aircraft, repair indexes, etc.

Introduction page. In order to use a particular -3 technical manual effectively, apply the instructions which appear on the introduction page. This page usually follows the list of illustrations and tells the purpose of the technical manual, how to locate repair information, etc.

Sectional arrangement. The -3 technical manual is usually arranged in the following sections: The *first* section, which is general, covers such information as aircraft data, investigating damage, repair preparations, support of the structure during repair, aircraft alignment, types of repairs, and control surface static balance. Other sections contained are on the wing group and the nacelle group. Each of these sections is broken down into smaller sections for further classification. A section of general information appears at the beginning of each main group. For example, in the wing group section, the units of the wing are

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STRUCTURAL REPAIR

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53-1491

Figure 2-2. Technical order title page.

listed. Each unit is then described and the term "station" is defined.

The section on extrusions has a page or two of general information listing extrusions used on the aircraft. The remainder of the section is composed of charts and illustrations. The illustrations give the standard number, die number, basic dimensions, substitutes, and material specifications.

Other sections may exist within the -3 technical manual, and the information therein may pertain to a variety of subjects. Thus, the miscellaneous section may include such things as cable repair, plumbing, hydraulic tanks, fuel tanks, and riveting procedures. Also, some structural repair technical manuals have an alphabetical index in the back. In using this latter index, it is helpful if you know the major heading of the specific information needed.

Exercises (416):

1. Which page of a technical order would you consult to check to make sure that you are using the correct TO for the aircraft being repaired?

2. Where would you check to see whether or not a repair illustration page is current?

3. What pages of a TO provide you with a quick reference source for station number diagrams, exploded views of the aircraft, and repair indexes?

LIST OF EFFECTIVE PAGES

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Change .... 1 .... 1 Jul 75

TOTAL NUMBER OF PAGES IN THIS PUBLICATION IS 1,562, CONSISTING OF THE FOLLOWING:

Page No.	Change No.
* Title	1
* A – B	1
* C Blank	1
* i – ii	1
iii – vii	0
* viii	1
ix	0
* x – xi	1
xii	0
* xiii	1
xiv	0
* xv	1
xvi – xvii	0
* xviii	1
xix – xx	0
* xxi	1
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xxiii – xxiv	0
* xxv	1
* xxvi Blank	1
* 1-1	1
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* 1-25 – 1-27	1
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* 1-44	1
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* 1-95	1
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* 2-155	1
2-156 – 2-176	0
* 2-177	1
2-178 – 2-187	0
* 2-188 – 2-189	1
2-190 – 2-211	0
* 2-212	1
2-213 – 2-225	0
* 2-226	1
2-227 – 2-251	0
2-252 Blank	0
* 3-1	1
3-2 – 3-16	0
* 3-17	1
3-18 – 3-32	0
* 3-33	1
3-34 – 3-40	0
* 3-41 – 3-42A	1
* 3-42B Blank	1
3-43 – 3-122	0
* 3-123	1
3-124 – 3-130	0
* 3-131	1
3-132 – 3-177	0
* 3-178	1
3-179 – 3-180	0
* 3-181 – 3-192	1
3-193 – 3-216	0
* 3-217	1
3-218 – 3-231	0
* 3-232	1
3-233 – 3-243	0
* 3-244	1
3-245 – 3-248	0
4-1 – 4-41	0
* 4-42	1
4-43 – 4-44	0
* 4-45	1
4-46 – 4-87	0
4-88 Blank	0
5-1 – 5-6	0
* 5-7	1
5-8 – 5-47	0
5-48 Blank	0
6-1 – 6-49	0
6-50 Blank	0
* 7-1	1
7-2	0

Upon receipt of the second and subsequent changes to this technical order, librarians shall ascertain that all previous changes have been received and incorporated. Action should be taken promptly if the publication is incomplete.

* The asterisk indicates pages changed, added, or deleted by the current change.

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Figure 2-3. Technical order "A" page.

BEST COPY AVAILABLE

LIST OF ILLUSTRATIONS

SECTION II WING GROUP

Figure	Title	Page
2-1	Wing Station Diagram	2-3
2-2	Diagram of Wing Primary Structure	2-4
2-3	Wing Breakdown Index	2-5
2-4	Wing Inspar Structure Index	2-6
2-5	Wing Skin Index	2-7
2-6	Wing Front and Rear Spar Diagram	2-9
2-7	Typical Wing to Body Splice Plate Diagram - BBL 70.5	2-10
2-8	Wing Stiffener Index	2-11
2-9	Wing Negligible Damage Inspar Structure	2-14
2-10	Splice Plate Allowable Damage	2-16A
2-10A	Front and Rear Spar Wing Attachment Pins Removal	2-16B
2-11	Wing to Body Splice Plate Replacement	2-18
2-11A	Replacement of Lightning Strike Armor Skin	2-24
2-12	Wing Skin and S-17, S-25 and S-6A Repair Upper Surface	2-24C
2-13	Lower Wing Skin and Stiffener Repair S-1, S-2 and S-3, Wing Buttock Line 64.38 - 129.62	2-28
2-14	Lower Wing Skin and Stiffener S-14 and Door Repair	2-30
2-15	Lower Wing Skin and Stiffener S-4 Repair	2-32
2-16	Lower Wing Skin and Stiffener S-8 and S-18 Repairs	2-34
2-17	Wing Skin and Stiffener Lower Panel Repair	2-36
2-18	Lower Wing Skin and Stiffener S-4, S-8, S-18 Repair Buttock Line 129 to Wing Station 733	2-38
2-19	Wing Skin Repair - Upper Panel	2-40
2-20	Typical Wing Skin Stiffener Repair	2-42
2-31A	Nacelle Aft Drag Support Fitting - Evaluation and Repair	2-72A
2-31B	Nacelle Aft Drag Support Fitting Replacement	2-72E
2-32	Wing Illustrated Index - Center Section	2-73
2-33	Wing Negligible Damage - Center Section	2-76
2-34	Wing Center Section Lower Panel Repair	2-80
2-35	Wing Center Section Upper Panel Repair	2-80
2-36	Spanwise Beam Lower Chord and Web Repair	2-84
2-37	Tee Stiffener Repair - Center Section	2-86
2-38	Spanwise Beam, Upper Chord and Web Repair	2-88
2-39	Wing Leading Edge Structure Index	2-90
2-40	Wing Negligible Damage - Leading Edge	2-95
2-41	Wing Leading Edge Rib Chord and Web Repair	2-96
2-42	Wing Leading Edge Rib Repair - Angle Chord	2-97
2-43	Rib Repair - Leading Edge Wing Stations 428.430 to 659.220	2-98
2-44	Wing Leading Edge Panel Stiffener Repair	2-99
2-45	Wing Leading Edge Panel Repair	2-100
2-46	Wing Leading Edge Crack Repair - Front Spar Station 716.72 to 736.80	2-101
2-47	Wing Leading Edge Rivet Hole Crack Repair	2-102
2-48	Wing Leading Edge Repair - Front Spar Station 107.2	2-103
2-49	Wing Leading Edge Repair Anti-Icing	2-104

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Figure 2-4. List of illustrations - TO page.

4. Information related to control surface balancing is usually found in what section of a TO?

5. Where are you likely to find a section of general information pertaining to a specific area of the aircraft?

417. Give specific limited factors influencing the sequence of procedures used to locate information in the -3 structural repair manual.

As an airframe repairman you will continually be using the -3 technical manuals. To accomplish your work successfully, you must know the arrangement and method of locating the information you need. This arrangement and method is not the same in every -3 technical manual, since the manufacturers and the various printers do not describe or illustrate their repair information in the same way.

For a better understanding of the -3 technical manual, we will discuss what to do in a theoretical case involving damage to the skin of the wing leading edge.

Step 1. Your first step is to make sure that you use the correct TO, for the correct aircraft. If you are making a repair on a KC-135, it would be a waste of

time and effort to be consulting a TO for a B-52. Always check the title page.

Step 2. Your second step consists of locating the individual section of the TO related to the damage area of the aircraft. The table of contents will provide this information. The table of contents, like the one shown in figure 2-5, outlines the order of the individual sections for the complete TO. For the repair situation stated earlier, Section 11, WING GROUP, would be the one to use.

Step 3. From this point on, our research procedures can be relatively simple or require additional steps. Your third step involves locating the repair illustration, if there is one. As we mentioned earlier, there is a list of illustrations for each section listed in the table of contents. If there is a specific repair illustration for the damaged area, turn to the page given. Your research is now completed. But, if there isn't a repair illustration listed, you must turn to the beginning of the group (section) related to the damaged area, given in the table of contents. Let us assume that an illustration for our repair situation was not listed, so we can follow through on the research procedures.

Step 4. After turning to the first page of the individual section, you will find a table of contents for that particular section, as figure 2-6 illustrates. You know that there isn't a specific repair illustration for the damage; so you will have to pinpoint the area within the section that pertains to the damage. The quickest way is for you to locate the page showing a breakdown of all of the components within the group. The WING LEADING EDGE STRUCTURE INDEX, given in figure 2-6, will fit your needs.

Step 5. Figure 2-7 illustrates the individual structures used in the construction of the leading edge. The individual structure, which is damaged, will determine

TABLE OF CONTENTS

Section		*Page*
	List of Illustrations	ii
	Introduction	xvi
	How to Use Manual	xvii
SECTION I	General	1-1
SECTION II	Wing Group	2-1
SECTION III	Tail Group	3-1
SECTION IV	Body Group	4-1
SECTION V	Landing Gear	5-1
SECTION VI	Nacelle Group	6-1
SECTION VII	Fabric Repair	7-1
SECTION VIII	Extrusion Chart	8-1
SECTION IX	Damage Due to Landing Gear Failure	9-1
SECTION X	Typical Repairs	10-1
	Alphabetical Index	1

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Figure 2-5. Table of content - TO page.

WING GROUP

contents

	page
General Description	2-1
Wing Station Diagram	2-3
Diagram of Wing Primary Structure	2-4
Wing Breakdown Index	2-5
Wing Inspar Structure Index	2-6
Wing Skin Index	2-7
Wing Stiffener Index	2-11
Wing Negligible Damage Inspar Structure	2-14
Wing Center Section Index	2-73
Wing Leading Edge Structure Index	2-90
Wing Trailing Edge Structure Index	2-108
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Inboard Aileron Index	2-162
Outboard Aileron Index	2-164
Spoiler Index	2-167

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Figure 2-6. Table of content - Individual section.

the next step. Take a few minutes, study figure 2-7, and see whether or not you can determine the next step. Notice, in the upper left-hand corner of figure 2-7, the note in the box, "Index numbers are repair figure numbers." The point of this note is to remind you not to confuse repair figure numbers with page numbers.

As you must have noticed, a repair figure number for repairing the skin portion of the leading edge is not given on the illustration itself (fig. 2-7). In this case, you must check all of the notes on the page for information. The second line, below the word "NOTES," is the information you need—"For typical skin repair see figure 10-5."

Step 6. This is normally the final step in the research procedure. The repair information given in figure 2-8 is a general repair that can be used on any section of the leading edge involving skin damage. Additional steps may be needed if the notes given on the repair illustration require them.

Exercises (417):

1. Give reasons why it is necessary to check the title page of the -3 structural repair manual when researching repair information.

2. What information given on the table of contents is necessary when researching repair information?

3. Why is the list of illustration an important key in researching repair information?

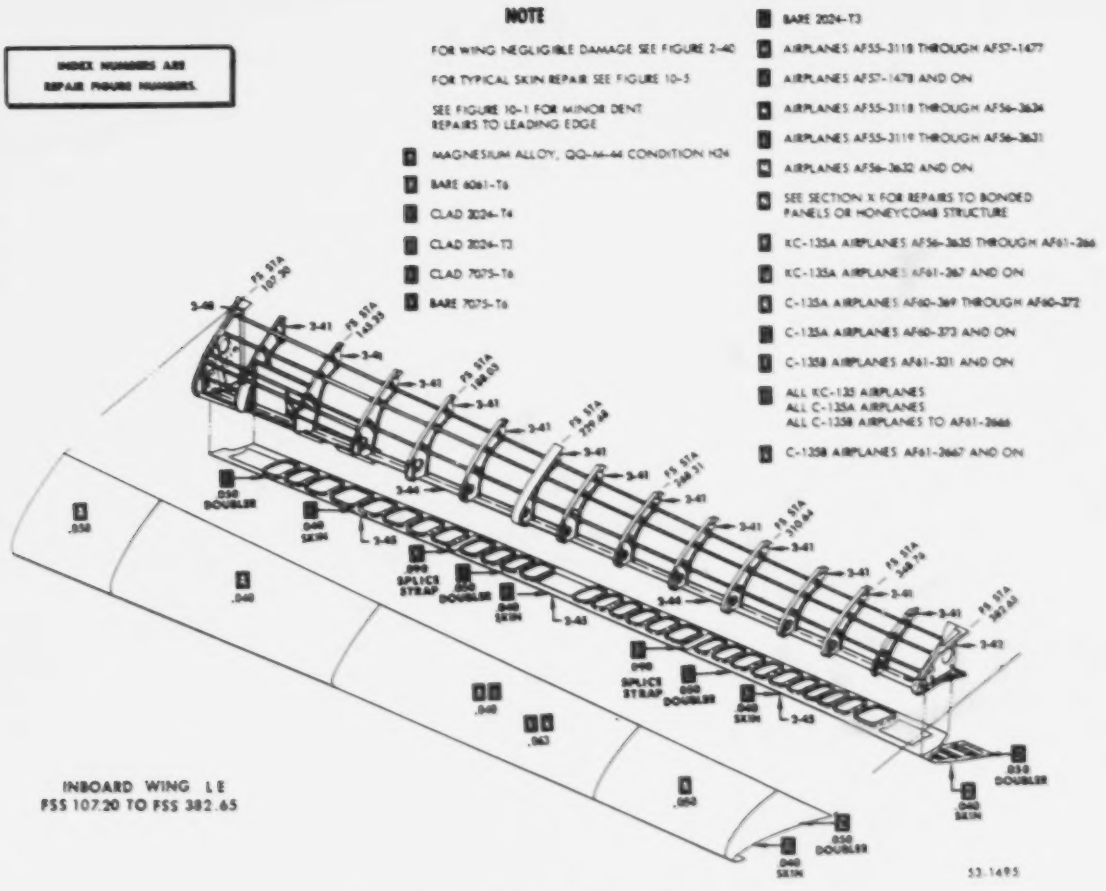


Figure 2-7. Leading edge structural index.

4. What is given at the beginning of each of the specific sections within a TO that will aid you in your researching?

5. Why should you check all notes given on repair illustrations?

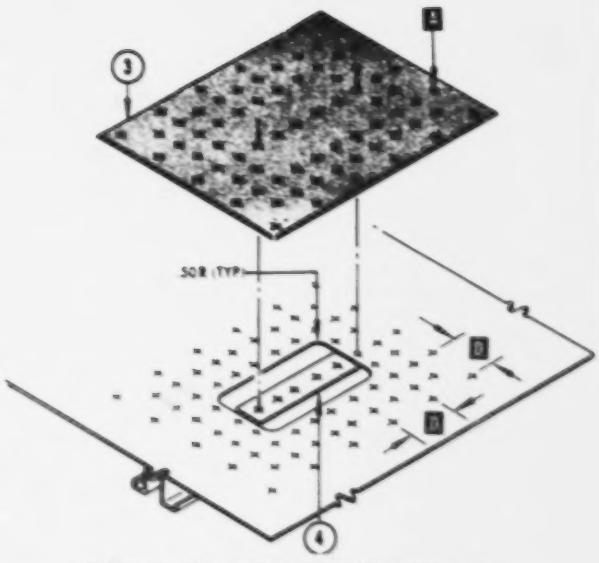
418. Point out and interpret specific data found on repair figures in the -3 structural repair manual by giving the designation, type, dimensions, style, or composition required in each instance.

Being able to locate repair information is the first requisite in properly using technical orders. The second requisite is being able to interpret the information shown, especially the symbols and abbreviations you should be most familiar with—which are the ones used for the fasteners and reference lines.

Reference Lines. Have you ever noticed on a globe of the world the lines (latitudes and longitudes) which run around it, both vertically and horizontally? One purpose of these lines is to enable people to locate any point on the globe by number. Some things which function similarly appear on aircraft drawings and repair illustrations; these are called reference lines. Reference lines are found on all major components of the aircraft, such as the fuselage, wings, stabilizers, or controls surfaces. The names of the reference lines are: (1) station, (2) water, and (3) buttock. How each is used and their abbreviations are outlined in the following paragraphs. Refer to figure 2-9, as we discuss the different reference lines.

Body station (BS). This is a vertical perpendicular to the vertical centerline plane of the fuselage, identified by its distance in inches from a vertical reference datum plane "X" number of inches forward of the nose of the airplane.

Wing station (WS). A plane perpendicular to the wing chord plane and perpendicular to the theoretical



REPAIR MATERIAL

(3) **1 PLATE**
ONE GAGE HEAVIER THAN SKIN
OR ONE GAGE HEAVIER THAN SKIN PLUS DOUBLER

(4) **1 FILLER**
SAME GAGE AS ORIGINAL

(5) **1 FILLER**
SAME GAGE AS SKIN OR
SAME GAGE AS SKIN PLUS DOUBLER

(6) **2 TAPERED FILLERS**
SAME GAGE AS PLATE

(7) **1 PLATE**
ONE GAGE HEAVIER THAN SKIN OR
ONE GAGE HEAVIER THAN SKIN PLUS DOUBLER
WHERE DOUBLER EXISTS

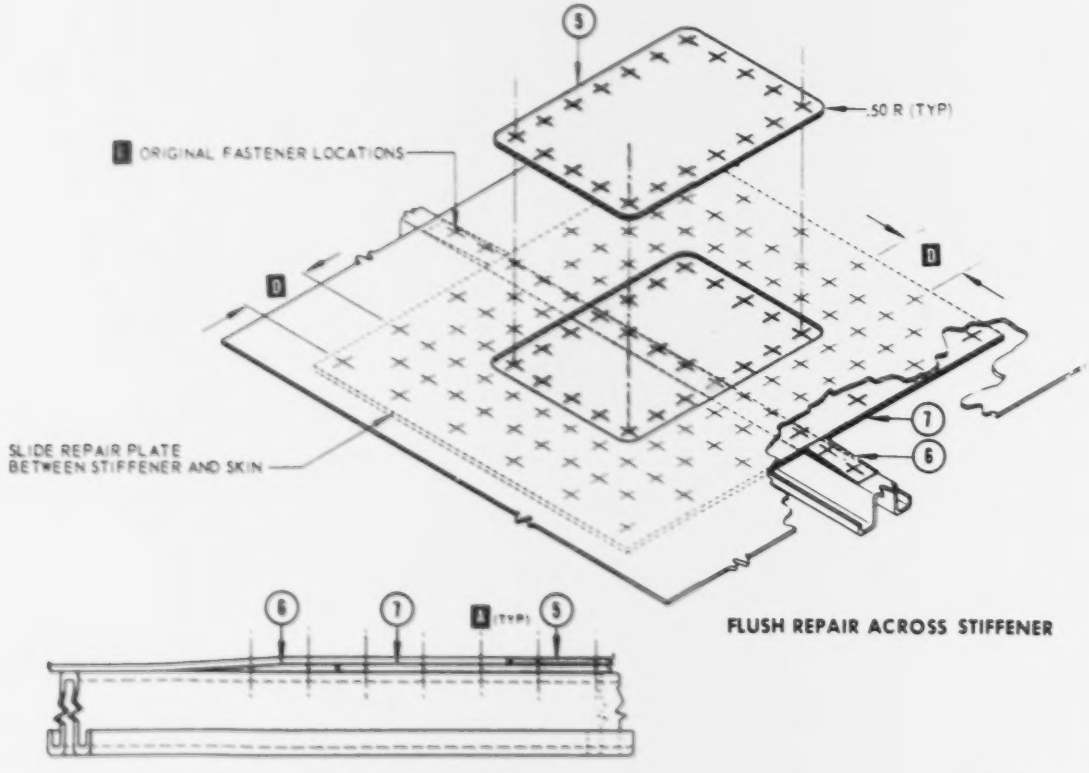


Figure 2-8. TO repair figure.

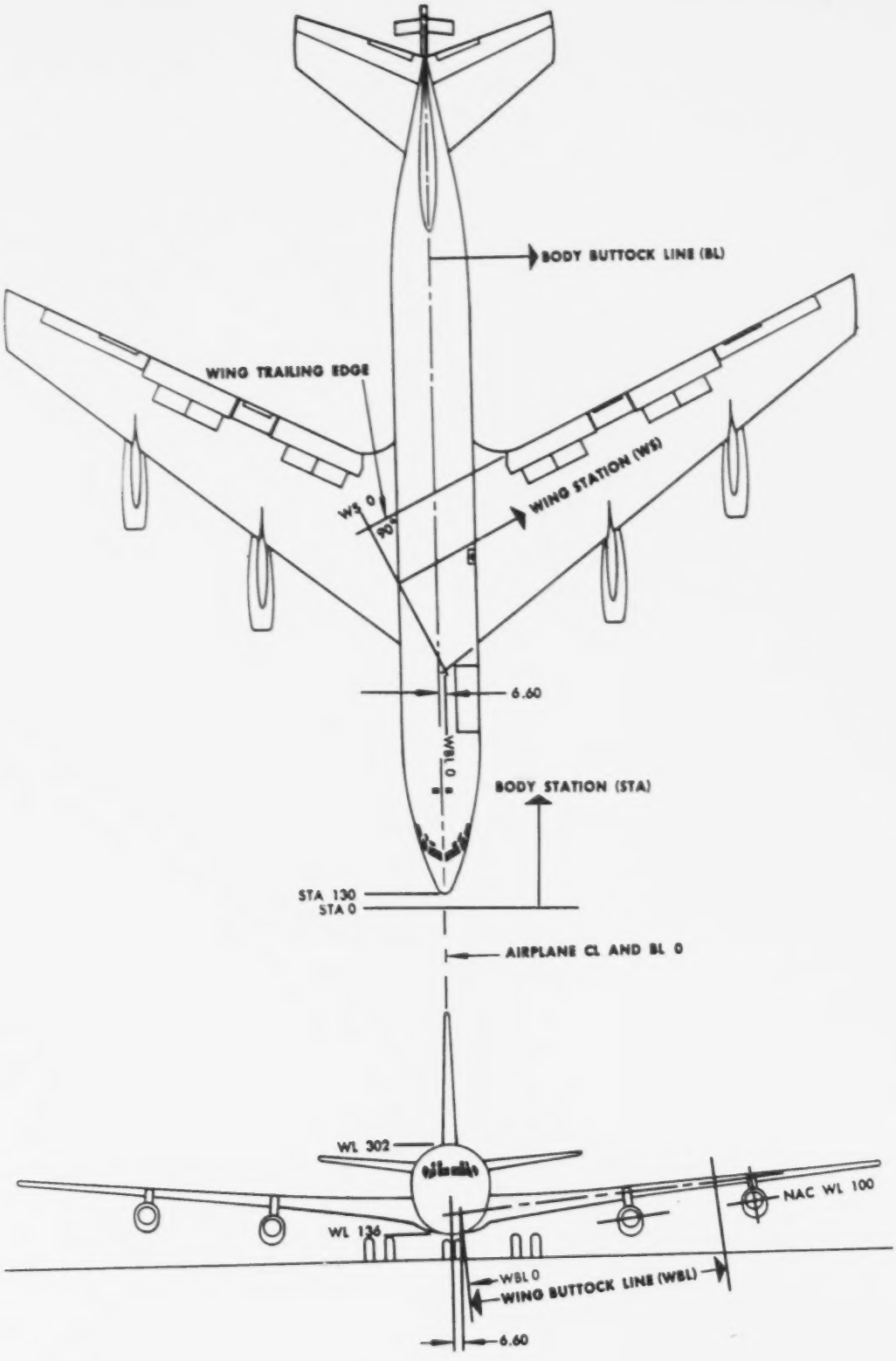


Figure 2-9. Reference lines.

wing trailing edge, and called the wing station (WS), is identified by its distance in inches to the right or left of an intersection of the wing leading edge and the vertical centerline plane of the fuselage.

Nacelle station (NS). The nacelle station (NS) is a plane perpendicular to the vertical centerline plane of each nacelle and perpendicular to a plane through the longitudinal centerlines of the engines, identified by its distance in inches from a reference datum plane.

Body buttock line (BBL). A line in a vertical plane parallel to the vertical centerline plane of the fuselage is called the body buttock line (BBL). It is identified by its distance in inches to right or left of the airplane centerline.

Wing buttock line (WBL). This is a line in a plane perpendicular to the wing chord plane and parallel to the longitudinal centerline of the fuselage. It is identified by its distance in inches to the right or left of the intersection of the wing chord plane and the vertical centerline plane of the fuselage.

Body water line (BWL). A line in a horizontal plane perpendicular to the vertical centerline plane of the fuselage and identified by its distance in inches from a horizontal reference datum plane is called the body water line (BWL). The reference datum plane is "X" number of low bottom of body.

Nacelle water line (NWL). The nacelle water line (NWL) is a line in a plane perpendicular to the vertical centerline plane of each nacelle and parallel to a plane through the longitudinal centerlines of the engines, identified by its distance in inches from a reference datum plane.

Fastener Symbols. The fasteners used in accomplishing repairs are identified by specific fastener symbols. Depending on the repair intended, a number of different fasteners might be used in making one repair. Figure 2-10 represents the system used in most technical manuals to identify the required fasteners. In the lower portion of this figure are some typical examples of fastener symbols.

The symbol is divided into four sections. The upper left-hand section indicates the type of fastener required. The upper right-hand section denotes the diameter of the fastener. The lower left-hand section shows the fastener installation process, and, lastly, the lower right-hand section depicts the material composition of the fastener. Note also figure 2-11, which provides more specific information about fastener types, dimensions, head styles, material composition, and identification numbers typically encountered.

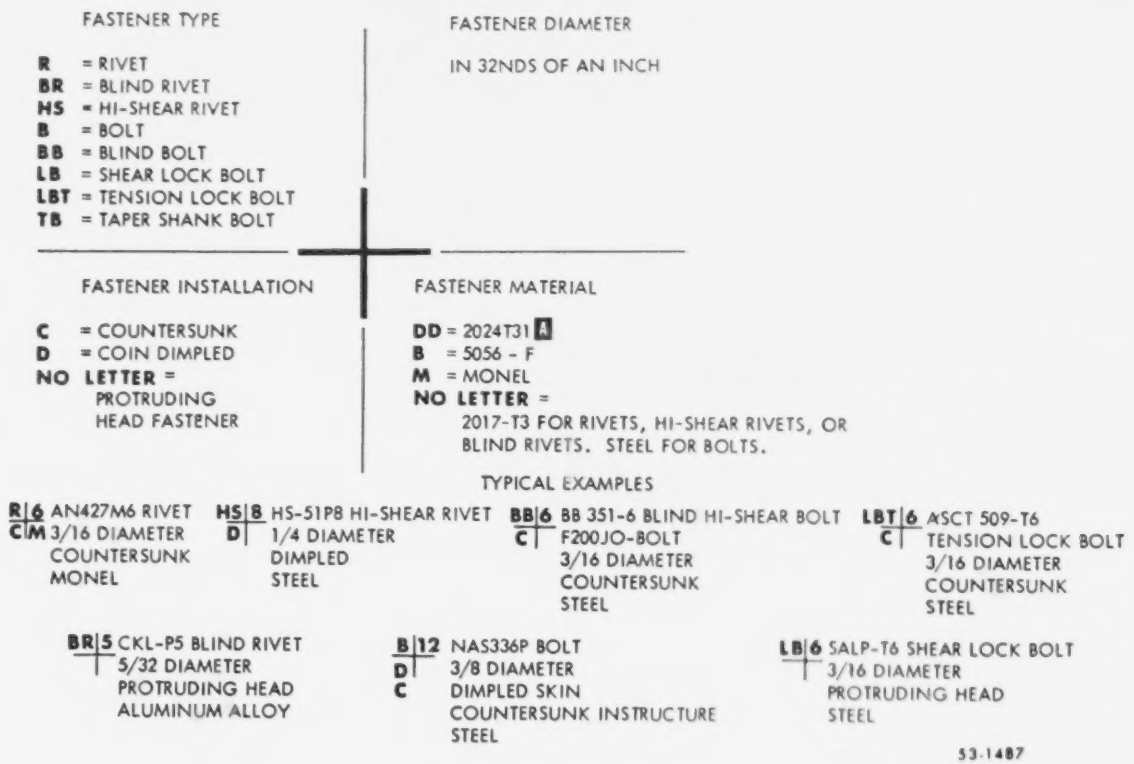

FASTENER TYPE
R = RIVET
BR = BLIND RIVET
HS = HI-SHEAR RIVET
B = BOLT
BB = BLIND BOLT
LB = SHEAR LOCK BOLT
LBT = TENSION LOCK BOLT
TB = TAPER SHANK BOLT
FASTENER DIAMETER
IN 32NDS OF AN INCH
FASTENER INSTALLATION
C = COUNTERSUNK
D = COIN DIMPLED
NO LETTER = PROTRUDING HEAD FASTENER
FASTENER MATERIAL
DD = 2024T31 A
B = 5056 - F
M = MONEL
NO LETTER = 2017-T3 FOR RIVETS, HI-SHEAR RIVETS, OR BLIND RIVETS. STEEL FOR BOLTS.
TYPICAL EXAMPLES
R|6 C|M AN427M6 RIVET 3/16 DIAMETER COUNTERSUNK MONEL
HS|8 D| HS-51P8 HI-SHEAR RIVET 1/4 DIAMETER DIMPLED STEEL
BB|6 C| BB 351-6 BLIND HI-SHEAR BOLT F200JO-BOLT 3/16 DIAMETER COUNTERSUNK STEEL
LBT|6 C| ASCT 509-T6 TENSION LOCK BOLT 3/16 DIAMETER COUNTERSUNK STEEL
BR|5 CKL-P5 BLIND RIVET 5/32 DIAMETER PROTRUDING HEAD ALUMINUM ALLOY
B|12 D C NAS336P BOLT 3/8 DIAMETER DIMPLED SKIN COUNTERSUNK INSTRUCTURE STEEL
LB|6 SALP-T6 SHEAR LOCK BOLT 3/16 DIAMETER PROTRUDING HEAD STEEL
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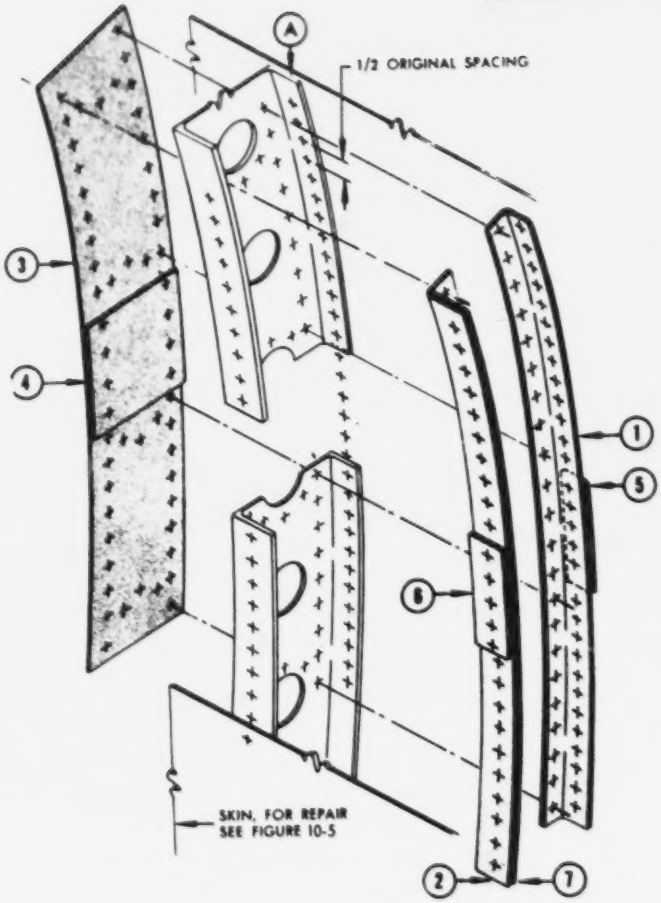
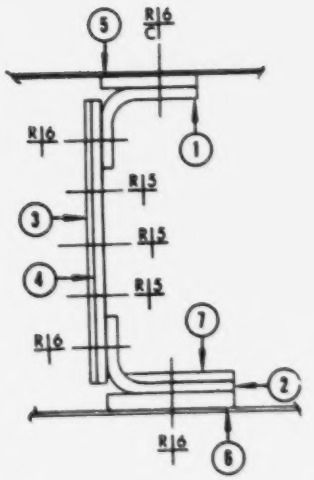
Figure 2-10. Fastener symbols.

REPAIR MATERIAL	LOCATION (BODY STATION)	
	426.35 AND 434.93	525.07 AND 533.65
(1) 1 ANGLE	.125 CLAD 7075-0 HT-T6	.125 CLAD 7075-0 HT-T6
(2) 1 ANGLE	.125 CLAD 7075-0 HT-T6	.125 CLAD 7075-0 HT-6
(3) 1 PLATE	.090 CLAD 7075-T6	.125 CLAD 7075-T6
(4) 1 FILLER	.090 CLAD 7075-T6	.125 CLAD 7075-T6
(5) 1 FILLER	.125 CLAD 7075-T6	.125 CLAD 7075-T6
(6) 1 FILLER	.160 CLAD 7075-T6	.25 CLAD 7075-T6
(7) 1 PLATE	.090 CLAD 7075-T6	.160 4130 STEEL HT 150,000-170,000 PSI CADMIUM PLATE FINISH
(A) ORIGINAL EXTRUSION	BAC1506-992 7075-T6	BAC1506-993 7075-T6





SECTION THROUGH DAMAGE

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Figure 2-11. Fastener repairs.

Exercises (418):

Refer to figure 2-9 as necessary for information needed to answer exercises 1 through 4.

1. What is the water line number for the top of fuselage shown in the figure?

2. What is the first body station number of the fuselage?

3. The first wing buttock line is measured how many inches from the top centerline of the fuselage?

4. What is the nacelle water line number for the longitudinal centerlines of the engines?

Refer to figures 2-10 and 2-11 as necessary for information needed to answer exercises 5 through 10.

5. What fasteners are used in the repair?

6. What is the diameter of the fasteners used in repair parts #1 and #5?

7. What is the head style of the fasteners used in repair parts #3 and #4?

8. What is the material composition identification numbers of the fasteners used throughout the repair?

9. What is the material thickness of repair part #4 for body station number 429.35?

10. What is the identification number for the original extrusion used at body station number 525.07?

419. Identify specific general repair manuals containing information relating to selected repair fields and/or areas.

A series of engineering manuals have been prepared to assist personnel maintaining and repairing aircraft. They contain general information on methods and procedures, or information that applies to all aircraft. Their use is limited in that the technical order governing the same area for a specific aircraft always prevail over the 1-1A series of manuals. You can use these manuals to obtain information on tools, equipment, materials, methods, and procedures when other technical orders do not give the desired information or are not available. Four of the manuals in this series are described below.

General Manual for Structural Repair, TO 1-1A-1. This manual is a result of conferences held by representatives of the Air Force, the Navy Bureau of Aeronautics, and the British Air Commission. It does not attempt to cover repairs on specific aircraft but deals with repairs so general as to apply to all aircraft. As far as possible, efforts have been made to coordinate repair practice in the three services. Actual working practice is the criterion applied to all information included and repairs covered.

Conditions under which repairs are made differ greatly. Thus, all materials, tools, and machinery needed to make repairs may be available, together with sufficient time and freedom from interruption, to allow striving for perfection. At other times, machinery may be lacking; materials and tools, few and wanting in quality; time, a pressing factor; and combat conditions, an actuality. Wherever possible, therefore, repairs in this manual are covered with two sets of circumstances in mind—operating under base repair conditions, and operating under combat area conditions. This dual coverage is *not* followed, however, where certain procedures must be used in all cases, because special tools and machinery are needed.

The instructions in the *General Manual for Structural Repair* are considered as general and applicable, except as otherwise specified in the manual for the specific aircraft. In cases of conflict between the handbook of instructions for the structural repair of a particular aircraft, subsequent technical orders, technical notes, or change orders, and the *General Manual for Structural Repair* or supplements thereto, the former should govern in all cases.

Structural Hardware, TO 1-1A-8. This manual contains concise and accurate information to aid in the selection and correct use of aircraft hardware.

Because of the small size of most hardware items, their importance is often overlooked. Yet the safe and efficient operation of any aircraft is greatly dependent upon the correct selection and use of aircraft hardware. To this end, this manual mainly covers structural hardware. However, certain nonstructural items, such as electrical wiring, tubing, and flexible hose, are also covered here.

The instructions in this manual are general and are applicable, except when otherwise specified in the manual for the specific aircraft. If there is a conflict between this manual and the manuals for a particular

aircraft, subsequent technical order, technical notes, or change orders, the latter should govern in all cases.

Aerospace Metals—General Data and Usage Factors, TO 1-1A-9. This manual contains concise information on metals to assist the services in selecting and preparing alternative metals for repair purposes. In all cases, of course, the services shall use the specified metals and the heat-treatment methods given in service specification and drawings when such materials and facilities for such treatments are obtainable.

Fabrication, Maintenance, and Repair of Transparent Plastics, TO 1-1A-12. This manual furnishes information related to transparent plastics. At present, this TO is only applicable to acrylics and modified acrylics. Information pertaining to polycarbondate-type plastics is contained in applicable -3 TOs.

Exercises (419):

1. General repair procedures are contained in which general engineering manual?

2. If you needed to identify a fastener head marking, which general engineering manual would you consult?

3. What general engineering manual outlines heat-treatment procedures for aircraft metals?

4. If you need information on how to repair acrylic plastics, which general engineering manual would you consult?

5. Working procedures related to tubing and flexible hoses can be found in which general engineering manual?

420. State the basic principles of repair and give examples of the methods used to maintain these principles.

Methods of repairing structural portions of the aircraft are numerous and varied. Information about design load acting in various structural parts of the aircraft are not always available to the field repairman. This is one reason why the problem of repairing a damages section is usually solved by duplicating the original part in strength, kind of material, and dimensions. Accordingly, the maintaining of original strength, weight, and proper contour must be foremost in your mind when you are making any repair.

Maintaining Original Strength. As you make a repair, you must observe certain fundamental rules so that the original strength of the structure can be maintained. Thus, make the patch plate have a cross-sectional area equal to, or greater than, that of the original damaged section. Again, if the member is subjected to compression or to bending loads, place the splice on the outside of the member in order to secure a higher resistance to such loads. If, however, you cannot place the splice in the outside of the member, use material of a weight next heavier than the weight of the material used in the original.

REMEMBER: Maintaining original strength is your main concern as you make any repair.

Material selection. Be sure that the material used in all replacements or reinforcements is similar to the material used in the original structure. If it is necessary for you to substitute an alloy weaker than the original, use material of a heavier gage to give an equivalent cross-sectional strength. Never practice the reverse; that is, never substitute a lighter gage, stronger material for the original. The reason for this apparent inconsistency is that one material can have greater tensile strength than another, but less compressive strength, or vice versa, as shown in the comparison of mechanical properties of alloys 2024T and 2024-T80.

Consider the substitution of alloy 2024T for alloy 2024-T80. Here the substitute material will have to be thicker unless the reduction in compressive strength is known to be acceptable. On the other hand, what if 2024-T80 material were substituted for 2024T stock? Here the substitute material will have to be thicker unless the reduction in tensile strength is known to be acceptable. Similarly, the buckling and torsional strength of many sheet metal and tubular parts are dependent primarily upon the thickness rather than the allowable compressive and shear strengths of the material. Therefore, a substitute thinner than the original will reduce considerably the buckling and torsional strength of a part, even though the thinner substitute material has higher compressive and shear strengths. You will find information on aluminim alloy sheet substitution in TO-1-1A-1, *General Manual for Structural Repair.*

When forming is necessary, be particularly careful. Heat-treated and cold-worked alloys will stand very little bending without cracking. Soft alloys, on the other hand, are easily formed but are not strong enough for primary structures. Strong alloys can be formed in their annealed condition and heat-treated to develop their strength before assembling.

In some cases, if the annealed metal is not available, you can heat the metal, quench it according to regular heat-treating practices, and form it before age-hardening sets in. The forming should be completed in

about half an hour after quenching or the material will become too hard to work. If you use a brake to form a section, place a thin piece of soft metal over the brake jaws to prevent scraping and scratching the surface of the sheet.

Fastener selection. You must consider a number of factors when selecting the correct fastener for a repair, including the following:

a. Areas of Application. The area on the aircraft where the repair is being made has a direct bearing on the type of fasteners required. For example, damage in an "open" area (access to the backside is unlimited) normally requires solid rivets. In contrast, in a "blind" area (access to the backside is not possible), a blind fastener is used.

b. Head Style. Concerning head style, you should consider the aerodynamic smoothness factor, based on limits outlined in the applicable -3 technical manuals.

c. Function of the damaged part. If the repair is located in a pressuruzed or fuel tank area, you need to give special consideration to the type of fastener used.

d. Diameter of rivets. Two methods exist for determining the diameter of the rivet required. In the first method, you determine the size of rivets by referring to the rivets (used by the manufacturer) in the next parallel rivet row inboard on the wing or forward on the fuselage. The other method of determining the size of rivets to be used is to multiply the thickness of the skin by 3 and use the nearest larger sized rivet corresponding to that figure. Thus, for example, if the skin thickness is 0.040 inch, multiply 0.040 by 3, which equals 0.120, and use the next larger size rivet, 1/8 inch (.125 inch).

e. Number of rivets required. All repairs made on structural parts of aircraft require a definite number of rivets in order to restore the original strength. This number varies according to the thickness of the material being repaired and the size of the damage. You can determine the number of rivets or bolts required by referring to a similar splice made by the manufacturer, or by using the following rivet formula: The number of rivets to be used on each side of the break is equal to the *length of the break* times the *thickness of the material* times 75,000 divided by the *shear strength* or *bearing strength* (whichever is the smaller of the two).

Now look at each separate term in this formula. In the order given:

- The *length of the break*—This is measured perpendicular to the direction of the general stress running through the damaged area.
- The *thickness of the material*—This refers to the actual thickness of the piece of material being repaired, and it is measured in thousandths of an inch.
- The 75,000 figure—As used in the formula, this assumes a stress load value of 60,000 psi and then increases this by a safety factor of 25 percent. It is a constant value.
- The *shear strength*—Taken from table 2-1, this is the amount of force required to cut a rivet holding two or more sheets of material together. Accordingly, if the rivet is holding two parts, it is under *single* shear; whereas if it is holding three sheets or parts, it is under *double* shear. NOTE: To determine the shear strength, you must know the diameter of the rivet to be used.
- The *bearing strength*—This is a value taken from table 2-2. It is the amount of tension required to either pull a rivet through the edge of two sheets riveted together or to elongate the hole. Note here that you must know the diameter of the rivet to be used and the thickness of material being riveted to use the bearing strength chart correctly. The diameter of the rivet would be the same as that you have used when determining the shear strength value. Thickness of material would be that of the material being repaired.

All right, let's assume that you now understand the derivation and meaning of each term used in the rivet formula (if not, read again the preceding paragraphs). You can reduce the formula to the following:

$$\frac{L \times T \times 75{,}000}{S \text{ or } B}$$

TABLE 2-1
SINGLE SHEAR STRENGTH TABLE

*Single Shear Strength of Aluminum-Alloy Rivets (Pounds)									
Composition of Rivet (Alloy)	Ultimate Strength of Rivet Metal (Pounds Per Square Inch)	Diameter of Rivet (Inches)							
		1/16	3/32	1/8	5/32	3/16	1/4	5/16	3/8
2117 T	27,000	83	186	331	518	745	1,325	2,071	2,981
2017 T	30,000	92	206	368	573	828	1,472	2,300	3,313
2024 T	35,000	107	241	429	670	966	1,718	2,684	3,865
*Double shear strength is found by multiplying the above values by 2.									

53450-3-3-T13

TABLE 2-2
BEARING STRENGTH TABLE

Thickness of Sheet (Inches)	Diameter of Rivet (Inches)							
	1/16	3/32	1/8	5/32	3/16	1/4	5/16	3/8
0.014	71	107	143	179	215	287	358	430
.016	82	123	164	204	246	328	410	492
.018	92	138	184	230	276	369	461	553
.020	102	153	205	256	307	410	412	615
.025	128	192	256	320	284	512	640	768
.032	164	245	328	409	492	656	820	984
.036	184	276	369	461	553	738	922	1,107
.040	205	307	410	512	615	820	1,025	1,230
.045	230	345	461	576	691	922	1,153	1,383
.051	261	391	522	653	784	1,045	1,306	1,568
.064		492	656	820	984	1,312	1,640	1,968
.072		553	738	922	1,107	1,476	1,845	2,214
.081		622	830	1,037	1,245	1,660	2,075	2,490
.091		699	932	1,167	1,396	1,864	2,330	2,796
.102		784	1,046	1,307	1,569	2,092	2,615	3,138
.125		961	1,281	1,602	1,922	2,563	3,203	3,844
.156		1,198	1,598	1,997	2,397	3,196	3,995	4,794
.188		1,445	1,927	2,409	2,891	3,854	4,818	5,781
.250		1,921	2,562	3,202	3,843	5,125	6,405	7,686
.313		2,405	3,208	4,009	4,811	6,417	7,568	9,623
.375		2,882	3,843	4,803	5,765	7,688	9,068	11,529
.500		3,842	5,124	6,404	7,686	10,250	12,090	15,372

Here is a fully developed use of this formula: Suppose you want to determine the number of 2117T rivets needed to repair a break 2¼ inches long in material 0.040-inch thick. Formula:

$$\frac{L \times T \times 75{,}000}{S \text{ or } B}$$

Information needed:

L = 2¼ (2.25) inches
T = 0.440 inch

Size of rivet: 0.040 X 3 = 0.120; so the rivet must be ⅛ inch, or 0.125.

S = 331 (from the shear strength chart)
B = 410 (from the bearing strength chart)
S = 331 is smaller than B = 410

Substitution and result:

$$\frac{2.25 \times .040 \times 75{,}000}{331} \times \frac{6750}{331}$$

Since any fraction must be considered as a whole number, the actual number of rivets required would be 21 for each side, or 42 rivets for the entire repair.

Maintaining Original Contour. Form all repairs so that they fit the original contour perfectly. A smooth contour is especially desirable when making patches on the smooth external skin of fast aircraft. Figure 2-12 illustrates the typical areas of an aircraft where aerodynamic smoothness is very critical.

Damages or repairs that change the contour or roughen the surface will cause a reduction in the performance of the aircraft. Thus, in aerodynamically critical areas, the change in performance will be serious

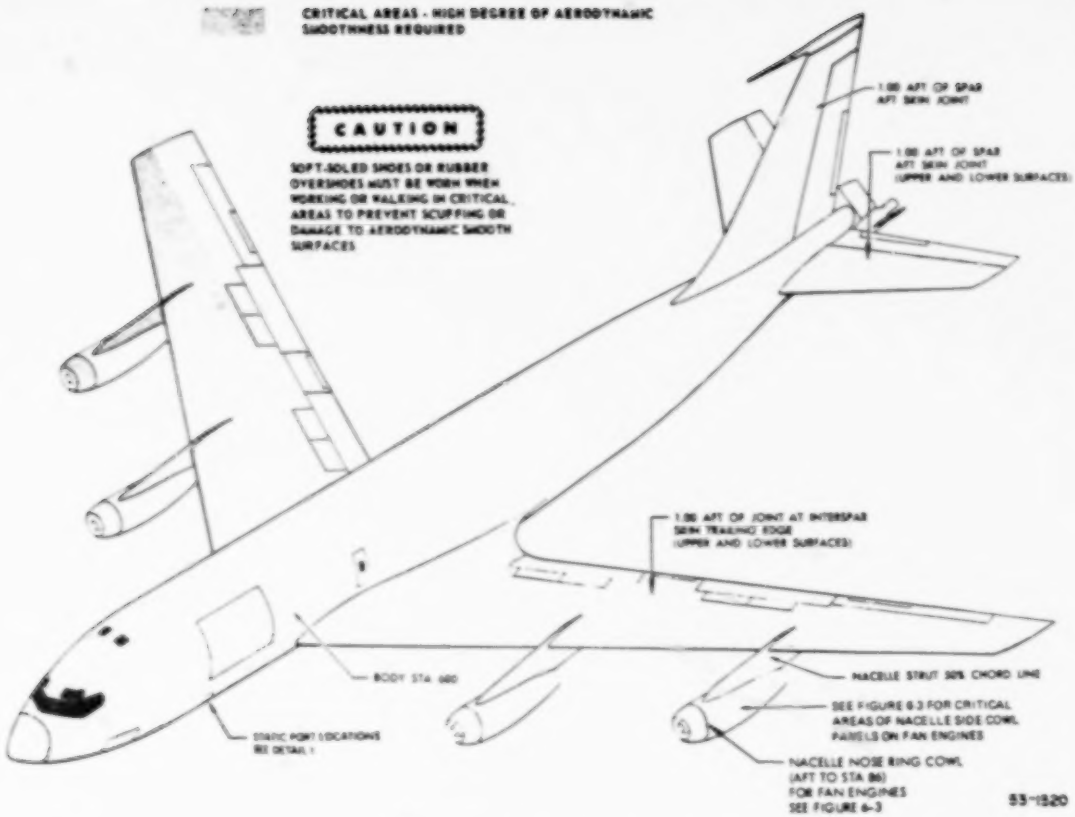

CRITICAL AREAS - HIGH DEGREE OF AERODYNAMIC SMOOTHNESS REQUIRED
CAUTION
SOFT-SOLED SHOES OR RUBBER OVERSHOES MUST BE WORN WHEN WORKING OR WALKING IN CRITICAL AREAS TO PREVENT SCUFFING OR DAMAGE TO AERODYNAMIC SMOOTH SURFACES
1.00 AFT OF SPAR AFT SKIN JOINT
1.00 AFT OF SPAR AFT SKIN JOINT (UPPER AND LOWER SURFACES)
1.00 AFT OF JOINT AT INTERSPAR SKIN TRAILING EDGE (UPPER AND LOWER SURFACES)
BODY STA 680
STATIC PORT LOCATIONS SEE DETAIL I
NACELLE STRUT 50% CHORD LINE
SEE FIGURE 6-3 FOR CRITICAL AREAS OF NACELLE SIDE COWL PANELS ON FAN ENGINES
NACELLE NOSE RING COWL (AFT TO STA 86) FOR FAN ENGINES SEE FIGURE 6-3
83-1320

Figure 2-12. Aerodynamic smoothness requirements.

unless you make every effort to maintain or match the original contour and surface smoothness. Any damage or repair which disturbs the normal flow of air over the critical areas of the wing will reduce the lift. This change may cause a slightly wing-heavy condition, or it could affect the stall characteristics, which would affect the aircraft's takeoff and landing speeds. The alteration could also cause buffering at high speeds. Thus, any changes to airflow around the control surfaces may affect effectiveness of the control.

Maintaining Original Weight. Keep the weight of all repairs to a minimum. To this end, make the size of the patch as small as practicable and use no more rivets than are necessary. Often repairs disturb the original balance of the structure. By adding excessive weight in each repair, you may unbalance the aircraft so much that it will require adjustment of the trim and balance tabs. In critical places, such as control surfaces, a repair may require the application of additional balance weights so that the control surface will be balanced within the limits outlined in the applicable -3 technical manual.

Exercises (420):

1. Name the three basic principles of repair.
2. How should the patch plate compare to the original damaged section in order to maintain original strength?
3. When is it necessary to substitute a lighter gage for the original material? What is the rule you should follow?
4. Cite two methods of determining the proper diameter of rivets to use in a repair.
5. What factors are used to determine the number of rivets required in a repair?
6. What effect does a change of contour have on the performance of an aircraft?

7. In what areas of an aircraft is the maintenance of the original weight very important?

421. Regarding selecting the shape and patch type to install in a given aircraft area, cite the determinant of exterior repair and the time to make specified patches, clarify the frequency of nonflush interior repair, and define "combination repair."

When you are assigned the task of repairing a damaged component or part of any weapon system, first consult the applicable section of the -3 technical order for that aircraft. Normally, a similar repair will be illustrated and the types of material, rivets, rivet spacing, and methods and procedures to be used will be listed. If you cannot find the necessary information in the -3 technical order, try to find a similar repair or assembly installed by the manufacturer of the aircraft.

Whether a damage is located on the exterior or in the interior of an aircraft will directly affect the type of patch you will install—external or internal.

External Patches. External patches are divided into two classifications: (1) flush and (2) nonflush. Which specific type to install is a major consideration you must make before starting the repair.

Flush skin repair. You can repair damage to the outside skin of an aircraft by applying a patch to the inside of the damaged sheet. Install a filter plug in the hole made by the removal of the damaged skin area. It plugs the hole and forms a smooth outside surface necessary for aerodynamic smoothness of modern-day aircraft.

You determine the size and shape of the patch by the size of the cutout and the number of rivets required in the repair. Thus, normally, the number of repair parts for a flush repair are two—a filler and a backing plate (doubler). However, in cases where a flush patch is made near a substructural member, up to four doublers may be needed. The doubler is fabricated from the same type of material as the original and should be one gage heavier than the skin panel. It acts both as a reinforcement to the repair area and as a surface for the attachment of the filler plate.

The filler plate is used to restore and maintain the aerodynamic shape of the skin surface. It should be manufactured from the same type and thickness of material as the original skin. Before the repair parts are fastened together, you should curve both the doubler and the filler to the precise contour of the repair area. Allow a maximum clearance of 1/32" between the edges of the filler and the skin. Aerodynamic smoothing compound can be used to fill this space and maintain skin smoothness.

Figure 2-13 shows typical flush skin repairs. For example, a circular repair is an ideal patch to use in places where the direction of the stress is unknown or where it is known to change frequently. Obviously, then, the actual shape of the repair will vary according to the locations of the repair.

Nonflush skin repairs. The nonflush skin repairs, shown in figure 2-14, are used primarily where aerodynamic smoothness is not critical and are permitted by the -3 technical order. When nonflush skin repairs are used in areas of aerodynamic importance, they are considered as temporary repairs, to be replaced as soon as practical.

Generally, repair patches are fabricated from the same material composition as the original material. The thickness of the patch is the same gage or one gage heavier, depending on the applicable guidelines in the -3 technical order. The edges of the patch are chamferred to a 45° angle and turned slightly downward, so that they will fit close to the surface, as illustrated in figure 2-15. Protruding head style rivets are generally used to hold the repair in place, unless otherwise specified in the applicable -3 technical order.

Internal Patches. Both flush and nonflush types of repairs can be used on the interior members of the aircraft. Nonflush types are most often used as a reinforcement plate, where damage has occurred. In contrast, flush type patches are used where the function or functions of other parts near the part being repaired require that the repair be flush. A large majority of repairs accomplished on the interior of an aircraft will involve some type of patching by insertion. Since it would be beyond the scope of this course to cover every possible type of internal repair, look briefly at figures 2-16, 2-17, and 2-18 to get a general idea of the various types of patches used.

There will be times when both an external and internal member of the aircraft, such as skin and stringer, will be damaged in the same area. You must therefore accomplish two types of patches when making such a repair. This type of repair is consequently called a combination repair.

Exercises (421):

1. What factor determines the type of repair required on the exterior of a fuselage?

2. When is it necessary for you to make a flush patch consisting of more than one doubler?

3. How are nonflush repairs most often used in repairing the interior structures on an aircraft?

4. When is a flush patch required on the interior structures of an aircraft?

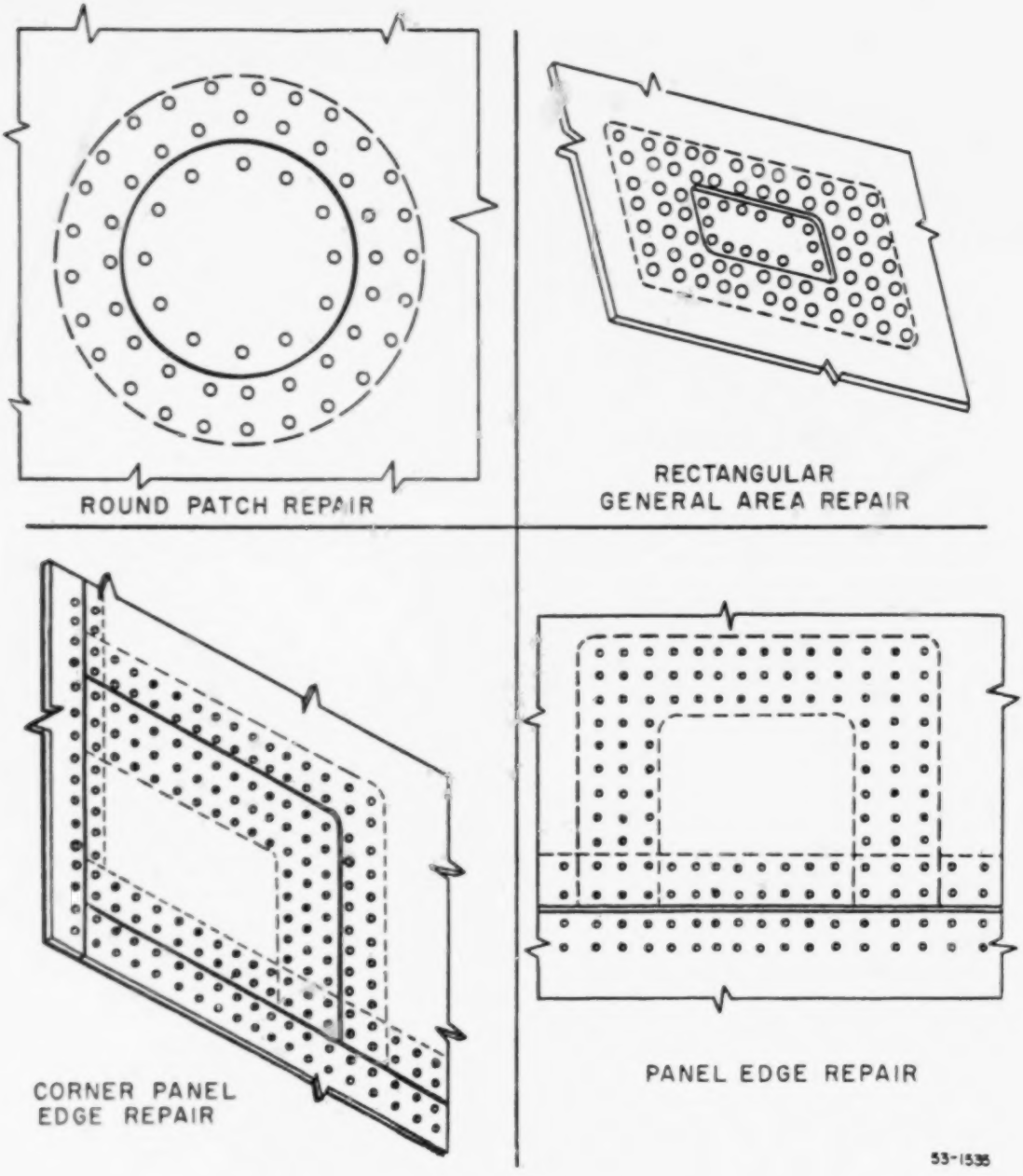


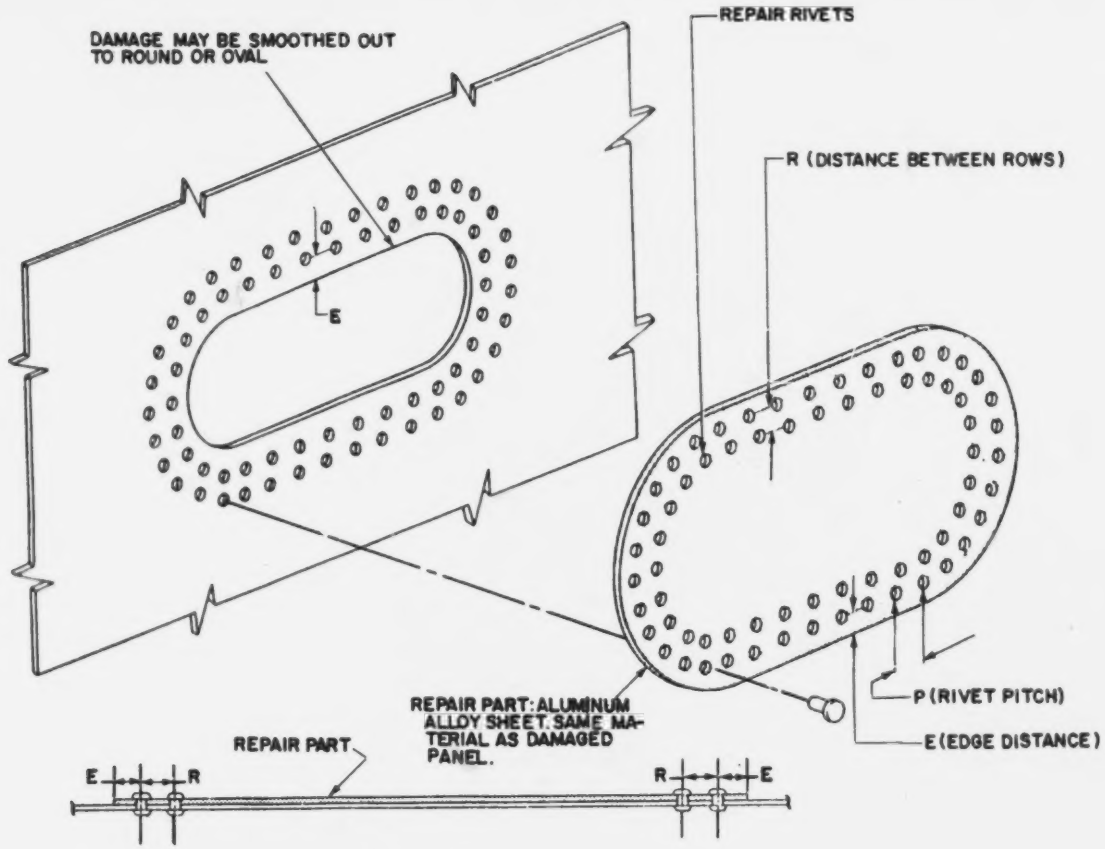
Figure 2-13. Configuration of flush skin repairs.

5. What is meant by the term "combination repair?"

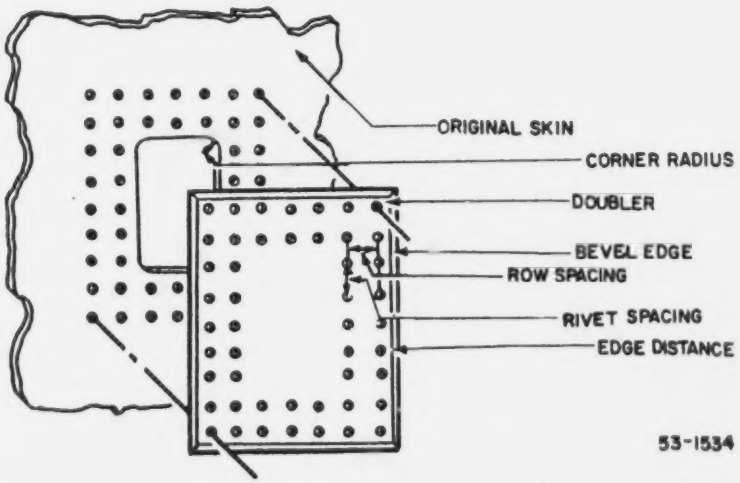
422. Tell why a clear description of technical problems is needed between worker and supervisor and identify other sources of assistance in solving technical problems.

In Volume 2 we have discussed the steps you should take as a future supervisor to resolve personal problems. However, a supervisor will encounter problems of a technical nature too. There is in such cases an established pattern that you should follow in order to resolve technical problems efficiently. This pattern is discussed in the following paragraphs.

Resolving Technical Problems. Your first step in resolving a technical problem is to adequately and



OVAL



RECTANGULAR

Figure 2-14. Typical non-flush skin repairs.

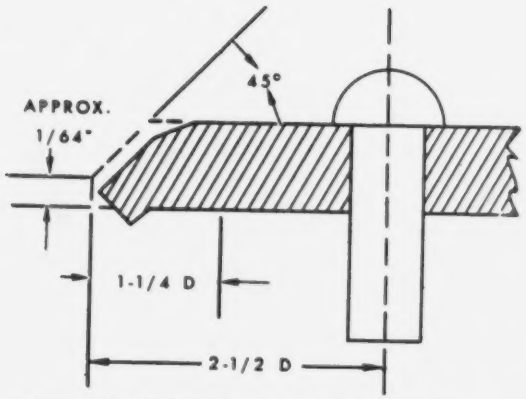
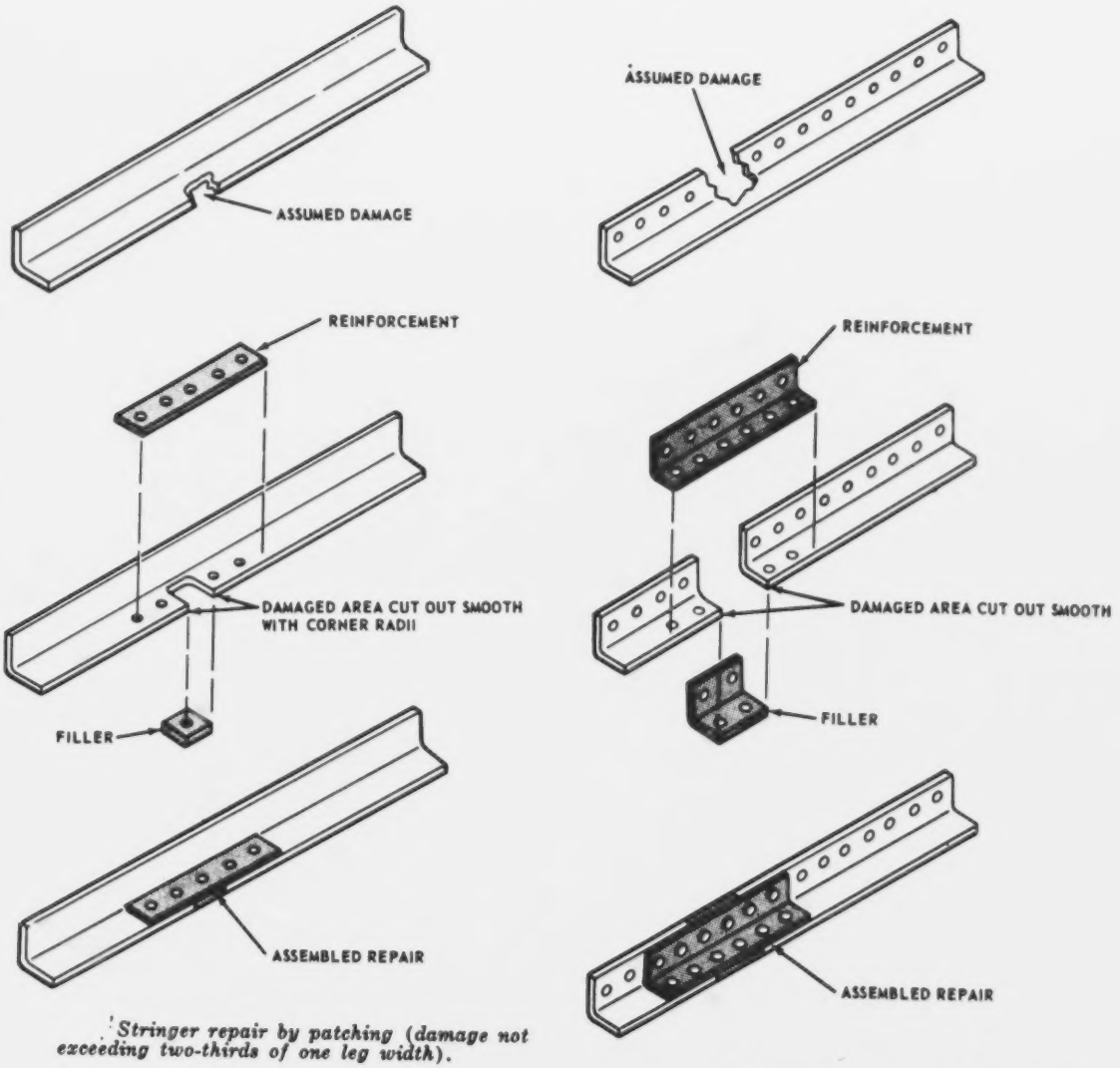


Figure 2-15. Chamfering and turning edges of patch.



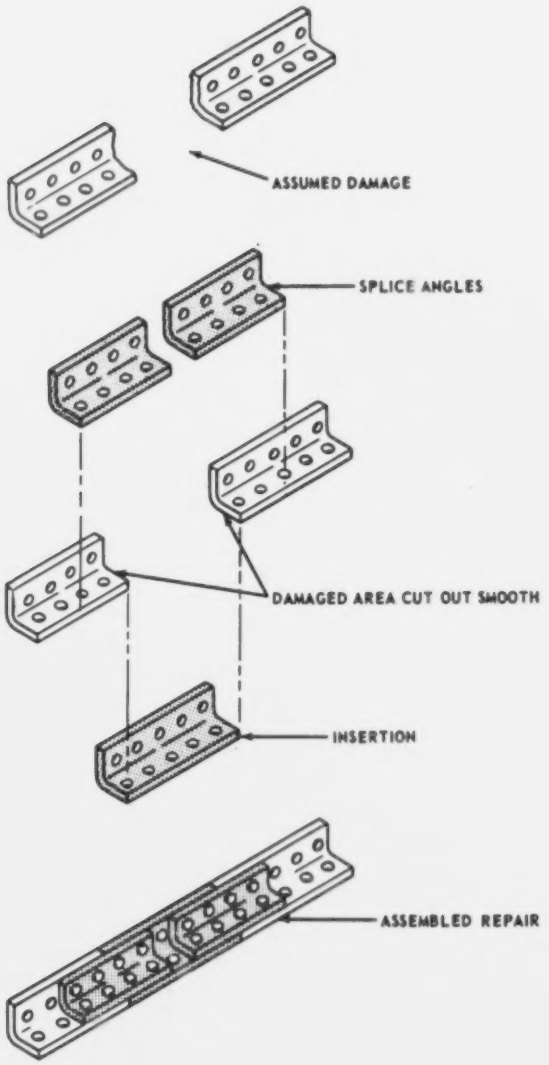
Stringer repair by patching (damage not exceeding two-thirds of one leg width).

Stringer repair by patching (damage exceeding two-thirds of one leg width).

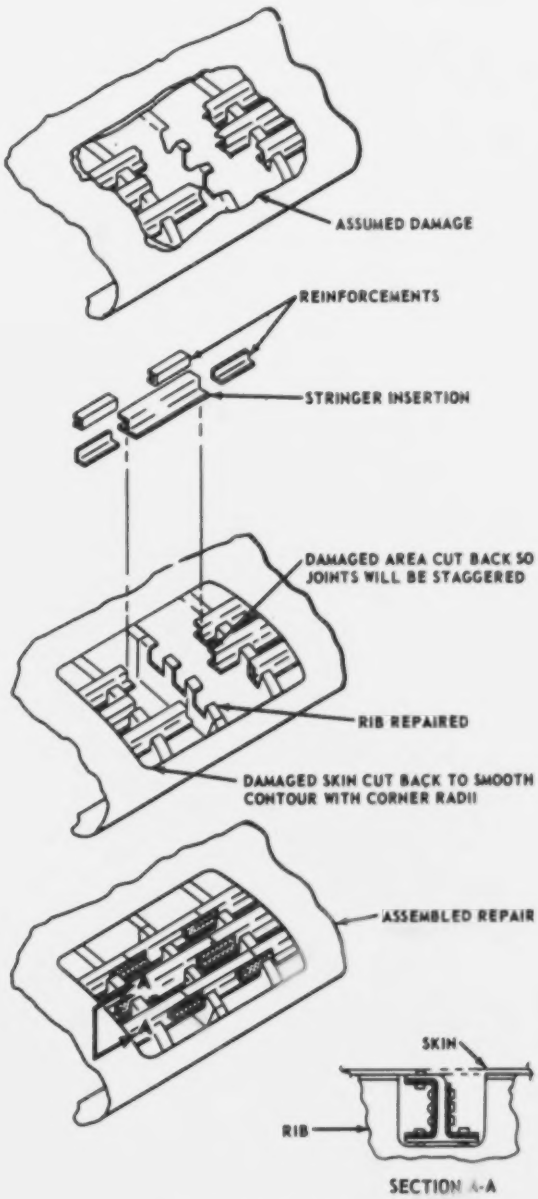
Figure 2-16. Stringer repairs by patching.

accurately define it. Without such a clear-cut definition of the problem, either you or your worker may not be striving for the correct solution. Often, too, if you ask your worker to state the problem correctly, he is thereby better able to understand it and to find the solution himself.

If, however, your worker seems unable to cope with the problem, you may have been given an excellent opportunity to both conduct spontaneous training, so that the worker can become more self-reliant, and to reinforce your own knowledge. For example, the worker may need a part but doesn't know how to order it. Here you help him resolve the problem by taking him through the procedures of ordering the part and explaining, as you proceed, the use of the necessary forms and supply documents that he must employ.



Stringer repair by insertion (damage affecting only one stringer).

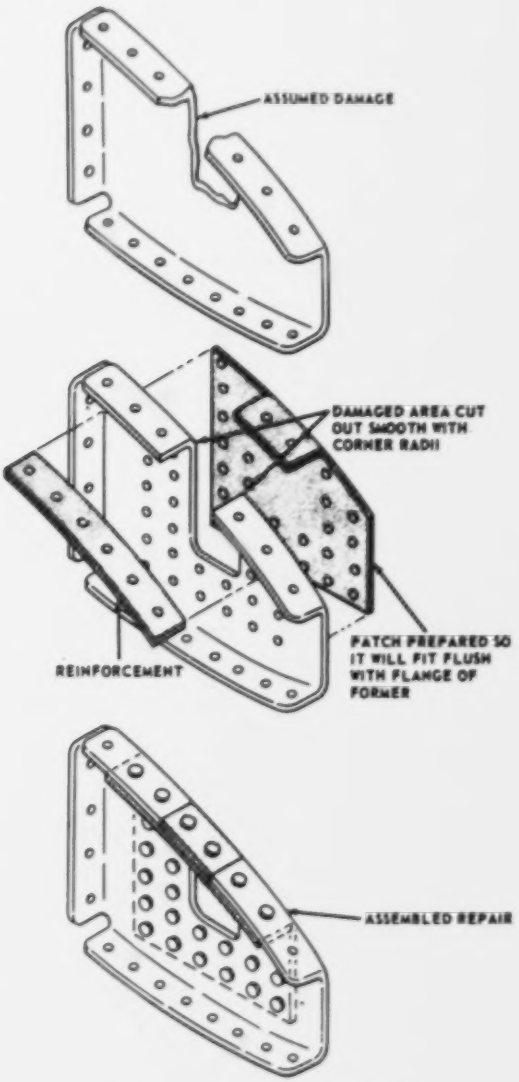


Stringer repair by insertion (damage affecting more than one stringer).

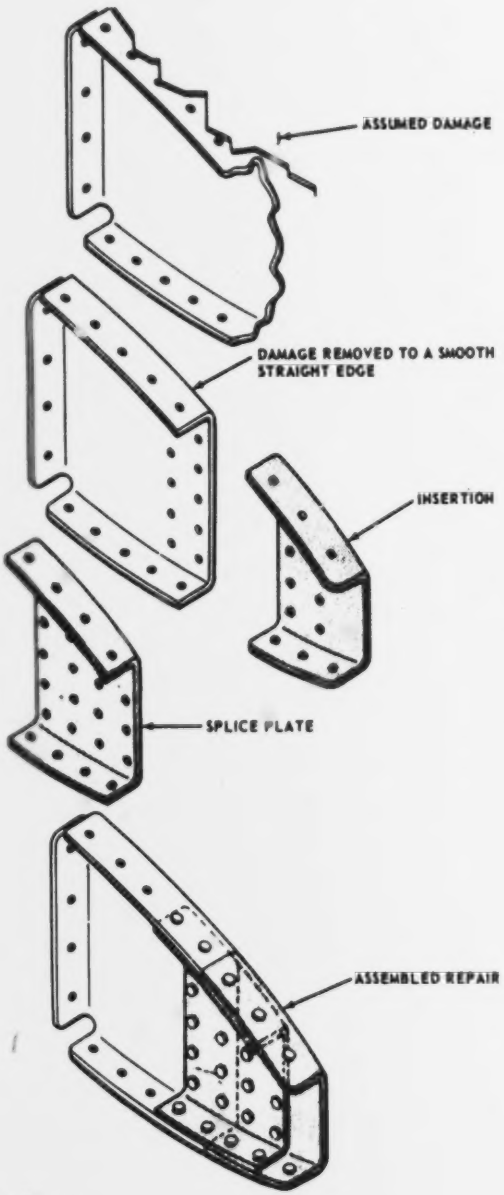
Figure 2-17. Stringer repairs by insertion.

Three other examples of technical problems your worker may meet with are related to (1) interpreting a technical order procedure, (2) reading a schematic correctly, and (3) making a positive fix on a honeycomb panel. Whatever the problem, you must try to help him resolve it and, at the same time, give him an explanation of the procedures required for its solution. If he is receptive, you may thereby increase his capability *and* the capabilities of your section.

Of course, sometimes the problem will be such that you are unable to resolve it with your worker. In such situations, first, be honest with yourself as well as with your worker; admit that you need assistance. Many sources exist to draw upon for help. Consider, for example, the first place to get help from your fellow workers. Obviously, in the course of daily maintenance, a number of problems arise that someone has already solved. Consequently, it is possible that *your*


ASSUMED DAMAGE
DAMAGED AREA CUT OUT SMOOTH WITH CORNER RADII
REINFORCEMENT
PATCH PREPARED SO IT WILL FIT FLUSH WITH FLANGE OF FORMER
ASSEMBLED REPAIR

Rib repair by patching.



Rib repair by insertion.

53-1532

Figure 2-18. Rib repairs by insertion and patching.

technical problem is "old hat" to one of your *co-workers.* Another source of help to consider is your own supervisor. Since it is likely that he has had many years of problem-solving experience, it is distinctly possible that he can put *his* finger on the solution to your problem. Then again, if he can't, by virtue of his experience and position, he can direct you to proper other sources for help—such as quality control, other knowledgeable technicians, technical representatives, and contractor assistance. Remember, no matter what technical problem you and your worker may encounter, you can be sure that a solution to it exists. Your real problem, then, is finding the best source of information for that solution. To this end, you must pursue every lead until you find it.

Exercises (422):

1. Why is a clear description of the technical problem necessary before a resolution can be made?

2. If you and your worker cannot come up with a solution to the technical problem encountered, where else could you go for assistance?

CHAPTER 3

Step II, Damage Removal and Fastener Layout

ONCE YOU HAVE completed all phases of the pre-repair procedures, such as inspection and research of repair procedures, you are ready to get into the actual processes of accomplishing the repair.

This chapter will deal with the processes of damage removal and the layout of fasterner patterns. The skill and workmanship you exhibit, while performing these processes, will have a direct bearing on the outcome of the repair. The saying "haste makes waste" is very true when anyone is removing damage and developing rivet patterns. So, always take a little extra time to make sure that all details are considered prior to starting the repair. It will pay off in quality work.

3-1. Damage Removal Procedures

A basic rule is that, when removing damaged areas, you must not cause MORE damage. What this means is that you must use the correct procedure and tools necessary, based on the location of the damage. Removal procedures, such as chain-drilling, skin knife techniques, and the use of specific types of power tools, will be covered in this section. Also, other factors which you must take into consideration when removing damaged areas will be covered in detail here.

423. Identify selected significant factors affecting the layout of the cutout for damage removal involved in making a flush skin repair and define an "open area."

Your first step in removing a damaged area is to decide how much undamaged area should be removed along with the damaged area. After calculating this, develop a layout of the cutout on the damaged area. This layout will serve as a guideline during the removing of the damage. Whether it is in an "open" area or near a substructural member, you must consider the location of the damaged area. Also, remember the final size of the patch, including the complete fastener layout, when you are developing the layout of the cutout. Let us examine the techniques required in this whole process, since different factors need to be considered in actually laying out the cutout.

Open Area. An "open area" is one where there is no substructural member, such as a stringer, within the damaged area. In such a case, your prime concern is removal of the damage. As you develop the layout of the cutout, remember that the correct size and the relieving of stress concentration are very important.

Cutout size. The size of the cutout should include anything that has changed the configuration of the area. The size of the cutout should be practical, so that you are able to develop a proper size patch. Don't miniaturize your cutout to a point where it would be difficult to use it to fabricate a filler plate. On the other hand, don't cut away an excessive amount of the undamaged skin area. As far as what the actual size of a particular cutout should be, you will have to make this decision based on your experience and your observation of the area you are repairing.

Stress relief. When damage cutouts are made other than circular cutouts, it is necessary to have a radius on the inside corners in order to prevent the creation of a high-stressed area at the corner of the cutout. The size of the corner radius is normally the same as the edge distance used for the fastener layout, unless a specific size corner radius is stated in the -3 technical order.

Substructural Areas. When a cutout must be made near or over a substructural member, other factors must be considered along with the removal of the damaged area. Two such factors are the edge distance from the cutout to nearset fastener and allowances for the fastener spacing required in the filler and doubler/s.

Cutout edge distance. The outer edges of the cutout must be edge distance from existing fasteners. This allows the proper edge distance to be maintained from the existing fastener to the edge of the cutout when the cutout is made. Also, at the same time, the location of the first row of fasteners needed for the doubler/s is established, as shown in figure 3-1.

Rivet spacing allowance. Rivet spacing allowance must be considered when the cutout area is near a substructural member. Notice, in figure 3-2, the lower section, the amount of space required on both sides of the cutout area for the fastener layout. However, it may be necessary to make the cutout area even larger, by extending the cutout over the substructural member to the opposite side, in order to have enough space for the required fastener layout in the filler and doubler/s.

Remember, as you develop a layout for the cutout, to consider the total area required for the repair parts.

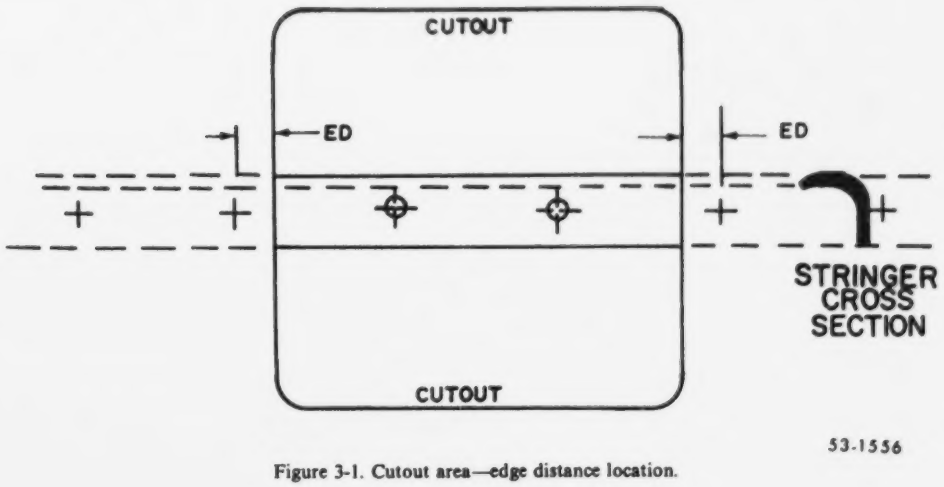


Figure 3-1. Cutout area—edge distance location.

Exercises (423):

1. Along with the amount of damage that must be removed, what other factors must be considered when you are making a cutout near a substructural member?

2. What is meant by an "open area"?

3. How are areas of stress concentration removed when you are making skin cutouts other than a circular cutout?

4. Why is it recommended that the cutout be edge distance from existing fasterners located in substructural members?

5. When would it be necessary to extend the size of cutout across a substructural member to the opposite side?

424. Specify the factors and procedures related to removing skin damage in an open area.

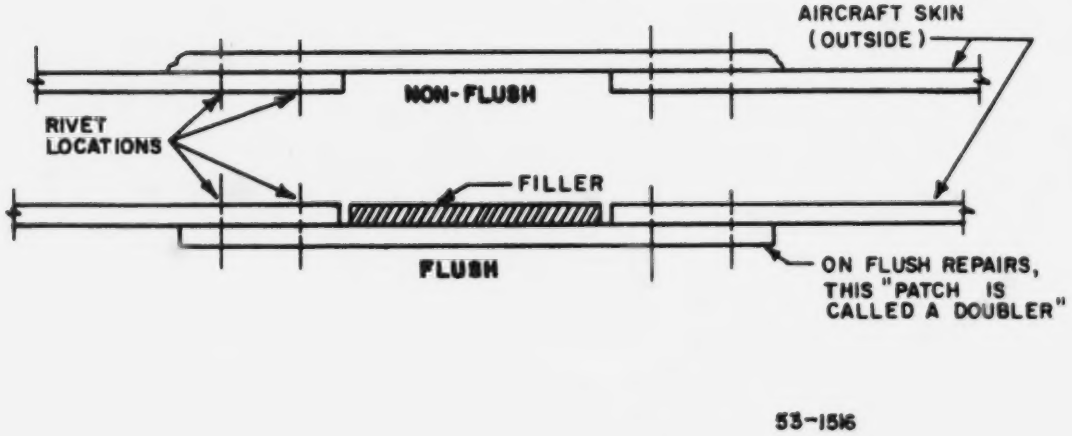


Figure 3-2. Cross-section of total patch requirements.

A number of methods are available for you to employ to remove damaged materials. The methods you use will depend on such factors as (1) the thickness of the material damaged, (2) location of the damage, and (3) the equipment located behind the damaged area, such as tubing, wiring, etc. Keep these factors in mind as we cover the various procedures/techniques used to remove damaged skin areas.

Chain Drilling. "Chain drilling" is a method of removing damaged material by drilling a series of closely spaced holes inside a cut line. When completed, the holes resemble a chain, thus the name "chain drilling." Removing damaged material by chain drilling requires caution. Here are the steps you should follow when chain drilling out a damaged area:

Step 1. After the layout of the cutout is complete, as shown in figure 3-3, part A, select a twist drill to use. The size twist drill used is directly related to the thick-

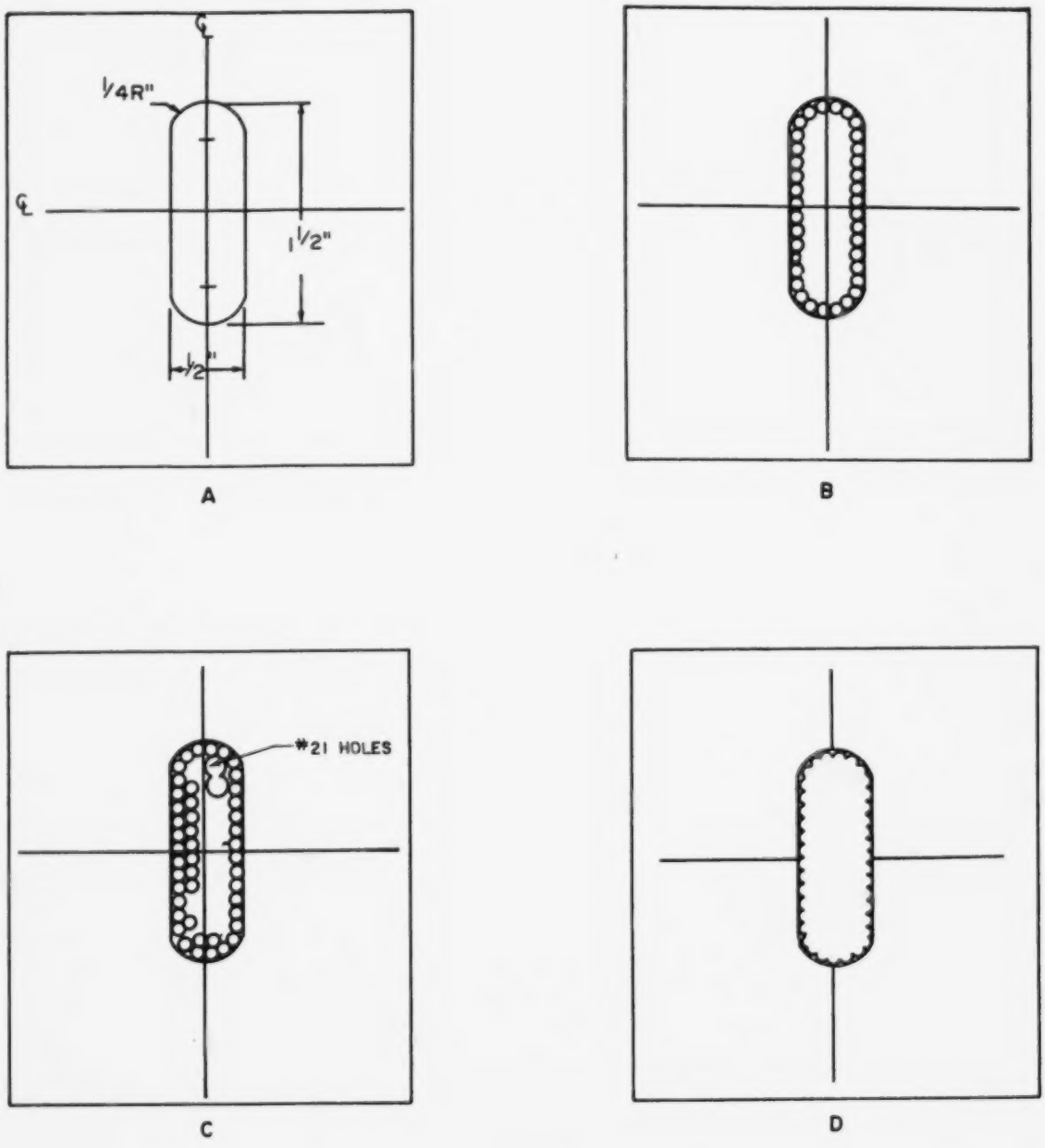


Figure 3-3. Chain drilling techniques — open area.

ness and material composition of the material being drilled. Generally, a #40 twist drill is used for aluminum alloys up to 0.050. For thicker aluminum alloys, a larger twist drill should be used. For materials requiring a high degree of drilling pressure, such as stainless steel and titanium, a #30 twist drill should be the smallest twist drill used.

Step 2. After selecting the proper twist drill, drill a continuous row of holes around the cutout, staying within the layout line. Keep the holes as close together as possible, as shown in figure 3-3, part B. Drilling the holes as close as possible makes it easier for you to remove the damaged area and reduces the amount of filling when you are smoothing the cutout edges. After drilling around the cutout, it is sometimes necessary for you to drill additional holes between the ones you have just drilled, if at first, the damaged area cannot be removed. However, if you chain drilled your holes as close together as possible, this procedure may not be necessary.

Step 3. Using a twist drill, large enough for inserting your long nose pliers, drill 2 or 3 holes close together to form a large hole in one corner of the cutout, as shown in figure 3-3, part C. Insert the pliers in the hole, grasp the damaged material, and work it back and forth until the material separates and comes out. Your cutout should look similar to the one shown in figure 3-3, part D.

Step 4. The last step in completing the damage removal is for you to file the cutout to the final dimensions of the layout. This should be done, in part, by your using a rotary file. The rotary file is used with the pneumatic drill to smooth down the burrs and rough edges left after chain drilling a cutout. Using a rotary file is much faster than hand filing, but this operation will not leave the edges in a finished condition. You must still finish the edges with a hand file and sandpaper. Figure 3-4, illustrates the various shapes of rotary files.

As with chain drilling, rotary filing requires careful use, because of the speed with which it removes metal. One careless slip, and the repair may be ruined. Therefore, use extreme care when you are employing this type of file. Certainly, used correctly, it can make a difficult job easier, but always exercise caution when using it.

Skin Knife Procedures. A "skin knife" is one used to make straight cuts in thin aluminum and magnesium alloys. Such a skin knife is usually fabricated from a discarded power hacksaw blade. The teeth of the hacksaw blade are ground away, a handle is attached to one end, and a hook-shaped cutting tip is formed at the other end. The sides of the cutting tip are tapered, so that a thin cutting line is produced when the skin knife is drawn across a piece of metal. Figure 3-5 shows a typical shaped skin knife. The advantages of a skin knife are: (1) it reduces the amount of chain drilling and filling and (2) it cuts the time required in making a cutout. Procedures for removing damage using a skin knife are somewhat similar to those used when chain drilling, with the noted exception in the amount of chain drilling required.

Step 1. After the layout is developed for the cutout, corner radii must be chain drilled in each corner of the cutout, as shown in figure 3-5. The reason for this is that because the skin knife should be used only to make straight cuts, and the chain drilled holes should serve as a stop when you are making cuts with the skin knife.

Step 2. Starting at one corner, draw the skin knife from the last chain drilled hole to the first hole in the opposite corner. In figure 3-5, this would be from corner A to corner B. Make sure you follow the layout line and apply a very light amount of cutting pressure at first. Repeat the sequence, gradually increasing the cutting pressure, once a guide track has been cut into the metal. The number of strokes required to cut through the metal will depend upon the thickness of the material. Alternating the cutting direction, from corner to corner, will insure the depth of the cut is equal along the cutting line.

Step 3. Once all sides have been cut, take a twist drill and drill holes large enough for insertion of your long nose pliers. Insert your pliers into the hole, grasp the damaged material, and work it back and forth until the material separates and comes out. You may have to make additional cuts with the skin knife if at first the metal doesn't separate.

Step 4. This consist of smoothing the edges of the cutout, using a rotary file and hand file as needed to the required dimensions.

Always use with the thought in mind that it can just as easily cut your hand as it can cut metal. Also, make sure, always, that no part of your body is placed in line with the direction of the cut being made. In this way, if you should slip, you are less likely to seriously injury yourself.

Additional Cutting Tools. Depending upon the thickness of the damaged area, you can use certain types of hand or power-operated cutting tools to remove a damaged area. Thus, aviation snips can be used, if the material is thin enough and the cutout area is large enough to permit their use. Likewise, circle cutters and hole saws can be used, if the damaged area

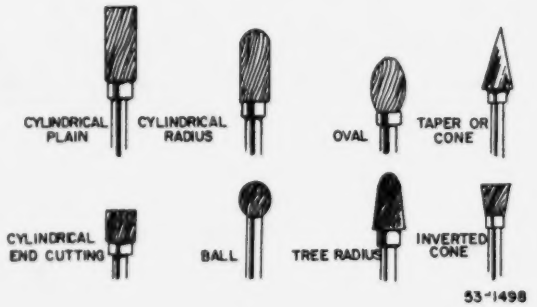


Figure 3-4. Rotary files.

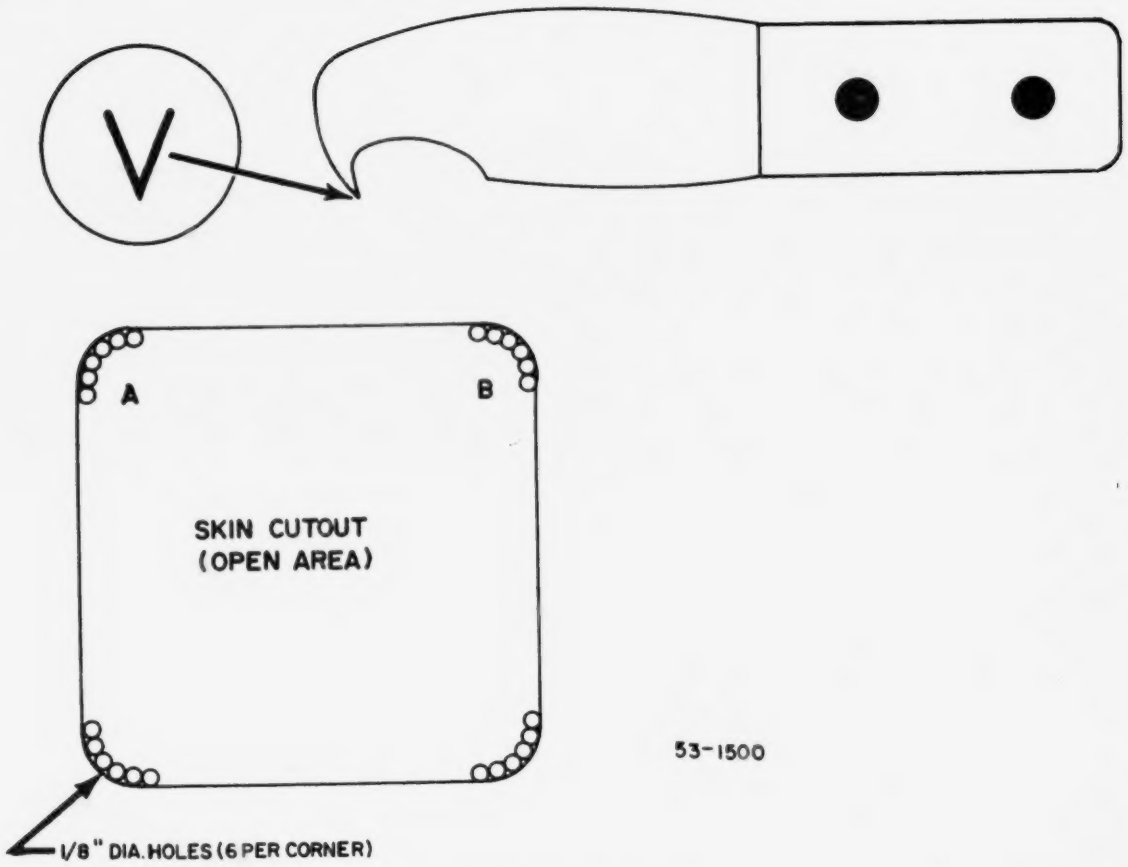


Figure 3-5. Skin knife procedures.

is such that a guide hole can be drilled. For thicker material, a reciprocating saw is the tool for you to use. Chain-drilled corner radii are normally required when you are using a reciprocating saw, because of the limited sizes of the radii that can be cut with the reciprocatng saw. The accuracy that can be accomplished with a reciprocating saw is such that you should make practice cuts on scrap material in order to check the operation of the saw prior to its use.

Exercises (424):

1. What factors must you consider in selecting the removal tools to use when making a cutout?

2. What factors determine the size of the twist drill used in chain-drilling a cutout?

3. How is the cutout area removed after the chain drill procedures have been completed?

4. Why is it necessary to chain drill the corners of a cutout when you are using a skin knife?

5. After the cutout area has been removed, either by chain drilling or by the using of a skin knife, state the procedures required to bring the cutout area to final dimensions.

6. When removing damage with a skin knife, what must you *not* forget?

7. What determines the amount of material removed by each cut of a skin knife?

425. Give step-by-step procedures for removing skin damage over a substructural member and state how necessary protection for the member is obtained.

When a substructural member is located within a damaged skin area, the procedures followed for removing the damaged skin must be modified. This is necessary in order to keep from damaging or adding to the damage of the substructural member.

Chain Drilling Procedures. When chain drilling over a substructural member, it is a problem not to drill into the substructural member. You can resolve this problem in a number of ways. One way, for instance, is to position a thin piece of metal between the skin and the substructural member. Removing a number of fasteners on both sides of the cutout area will loosen the skin enough so that the metal can be inserted. This piece of metal will serve as a step when drilling over the substructural member. Drill only through the top skin until you reach the scrap piece of metal. Once you have removed the cutout area, retain the scrap metal in place during rotary file operation over the substructural member.

In areas where it is impossible to insert a scrap piece of metal between the members, be extremely cautious and drill only deep enough into the top skin until the twist drill starts to break through the backside. This procedure is easier said then done; so be extra careful. The material left by your not drilling all of the way through the skin can be rotary filed away, once the cutout area has been removed. Insert a scrap piece of metal between the member when rotary filing, as shown in figure 3-6.

Skin Knife Procedures. When removing a damaged skin over a substructural member, the use of a skin knife is the preferred method. This procedure eliminates the problem created by using the chain drilling procedure, i.e., drilling into the substructural member. When cutting very thin skin material, such as 0.025 and below, regulate the cutting pressure so as not to cut into the substructural member. After the cutout has been removed, insert scrap material between the members during the rotary file operations.

Additional Cutting Tools. In this whole process, the use of hand or powered-operated cutting tools would be very limited because of the substructural member involved. If, however, the repair structure is such that hand or power-operated tools *can* be used, protection of the substructural member should be foremost in your mind.

Exercises (425):

1. How is the substructural member protected from damage when you are chain drilling a cutout over the member?
2. The protection required in performing the task posed in exercise 1, above, may be removed at what point in the repair process?
3. What procedure should you follow when you are chain drilling a cutout over a substructural member where access to the backside of the damage area is not possible?
4. When is the protection of the substructural member necessary when you are using a skin knife to remove the damaged skin?
5. How can you insure that the substructural member is not damaged when you are using a skin knife to cut very thin material where access to the backside of the cutout is not possible?

426. Cite specified procedures for removing part of a damaged substructural member and give the reasons for perpendicular sides for substructural cutout and for keeping all damaged parts until repair is completed.

Your attention now is directed toward the procedures used to remove a damaged substructural member. For our purpose here, damage occurring to a stringer will be high-lighted. The procedures and consideration factors associated with removing a damaged portion of a stringer can also be applied to other

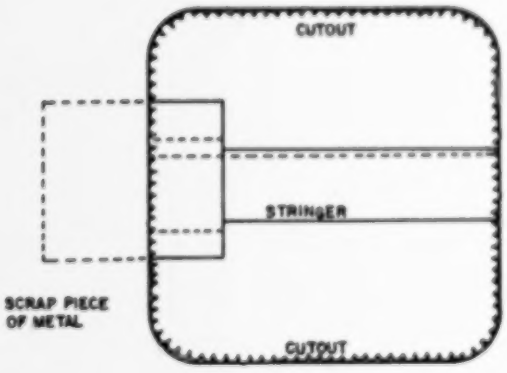


Figure 3-6. Chain drilling techniques — over a substructural member.

substructural members. Keep in mind that whenever you are removing a damaged area, be careful not to damage surrounding structural members of equipment.

Cutout Size. Along with removing the damaged portion, you must consider the location of existing fasteners in the stringer when you are determining the size of the cutout required. Also, proper edge distance must be maintained from the edge of the cutout to the first fastener, on both sides of the cutout.

Where a damage requires both a skin and stringer cutout, the size of the cutouts should be the same, unless the damage to either one would make this impractical. In such a case, separate cutouts are needed, each with the proper edge distance requirements.

Removal Techniques. When the stringer cutout is the same as the skin cutout, you can use a reciprocating saw to cut out the stringer. However, you may use a hacksaw if the skin cutout is large enough. In any case, the sides of the stringer cutout must be perpendicular (90°) from the skin cutout. This is necessary to insure a proper fit of the stringer filler section when you are installing the repair parts.

In areas where the stringer cutout is larger than the skin cutout, you must insert a scrap piece of metal between the skin and stringer to prevent damaging the skin. Figure 3-7 illustrates this technique. Chain drilling can then be accomplished, if you make sure not to drill through the scrap piece of metal into the skin. You may need to use an angle drill to chain drill the horizontal flange of the stringer, depending upon the location of the stringer and adjacent internal structures. After the damaged portion has been removed, use a rotary file to remove the rough edges, after which you can use a hand file. All bits and pieces of the damaged area removed should be retained until the repair is completed. Why? Because if may be necessary to refer to them for necessary information, such as the alignment of parts, overall dimensions, location of fasteners holes, etc.

Exercises (426):

1. What should be foremost in your mind when you are removing a damaged substructural member?

2. When the substructural member's cutout and the skin cutout are the same, what tools can you use to remove the damaged substructural member?

3. Why should the sides of a substructural cutout be perpendicular from the skin cutout?

4. What removal procedure is normally used to remove a damaged substructural member when the cutout is larger than the skin cutout?

5. In the repair situation stated in exercise 4, what must you do to protect the skin from damage?

6. Why may it be necessary for you to use an angle drill when removing a damaged substructural member?

7. Why is it recommended that all damaged parts be retained until the repair is completed?

3-2. Fastener Layout Techniques

When the cutout is completed, the next phase of the repair process is to develop the fastener layouts (patterns). In general, try to make the spacing of the fasteners on a repair conform to that used by the manufacturer in the area surrounding the repair. Aside from this fundamental rule, there is no specific set of rules which governs the spacing of fasteners in all cases. For specific rules, you should consult the -3 technical order for the aircraft being repaired.

Since most of the fasteners you will use are rivets, our discussion will be centered on them. There are certain minimum requirements which you must observe to insure that the repaired area is returned to its original load-carrying capabilities.

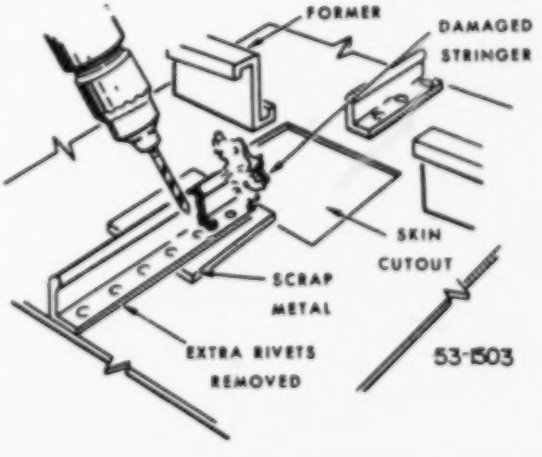


Figure 3-7. Stringer damage removal.

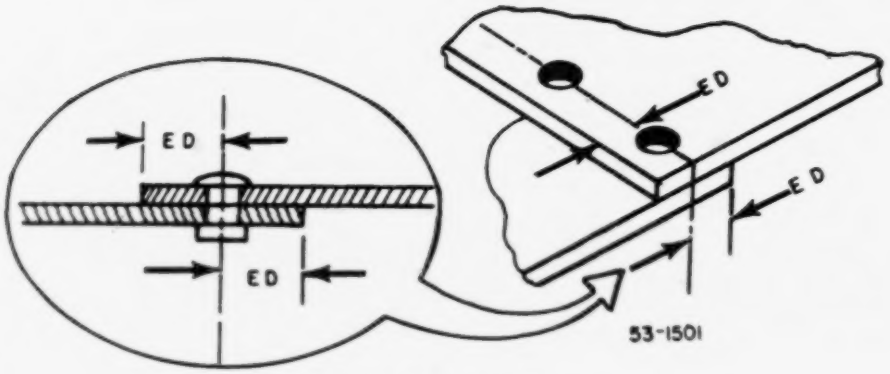


Figure 3-8. Edge distance.

427. Name three terms used in laying out solid rivets and give the general spacing rules associated with each term.

Earlier in our discussion of cutout procedures, we stressed the need for proper edge distance in making any cutout. The term "edge distance," along with the terms "rivet pitch" and "transverse pitch," are used throughout any repair manual dealing with sheet metal repair. As an airframe repair specialist, you must know the meaning of these terms and the rules governing their use, because you will be continually using them.

Edge Distance. The edge distance, or distance from the center of the first rivet to the edge of the sheet, should not be less than 2 rivet diameters nor more than 4. The recommended edge distance is about 2½ rivet diameters. If you place rivets too close to the edge of the sheet, the sheet is likely to crack or pull away from the rivets. If you space them too far from the edge, the sheet is apt to turn up at the edges. Figure 3-8 illustrates how edge distance is applied.

Rivet Pitch. Rivet pitch is the distance between the centers of neighboring rivets in the same row. The smallest allowable rivet pitch is 3 rivet diameters. The average rivet pitch usually ranges from 6 to 8 rivet diameters, although rivet pitch may range from 4 to 10 rivet diameters.

Transverse Pitch. Transverse pitch is the perpendicular distance between the rivet rows. It is usually equal to 75 to 100 percent of rivet pitch. The smallest allowable transverse pitch is 2½ rivet diameters. Figure 3-9 illustrates how rivet pitch and transverse pitch is indicated.

General Spacing Rules. The general rules of rivet spacing, as applied to straight-row layout, are quite simple. In a single-row layout, first, determine the edge distance as each end of the row; then lay off the rivet pitch (distance between rivets), as shown in figure 3-10. In the two-row layout, lay off the first row as just described, place the second row a distance equal to the transverse pitch from the first row, and then lay off rivet spots in the second row so that they fall midway between those in the first row. In a three-row layout, lay off the first and third rows; then determine the second row rivet spots by using a straightedge. (See fig. 3-10).

When splicing a damaged tube where the rivets pass completely through the tube, space the rivets 4 to 7 rivet diameters apart if neighboring rivets are at right angles to each other. Space them 5 to 7 rivet diameters

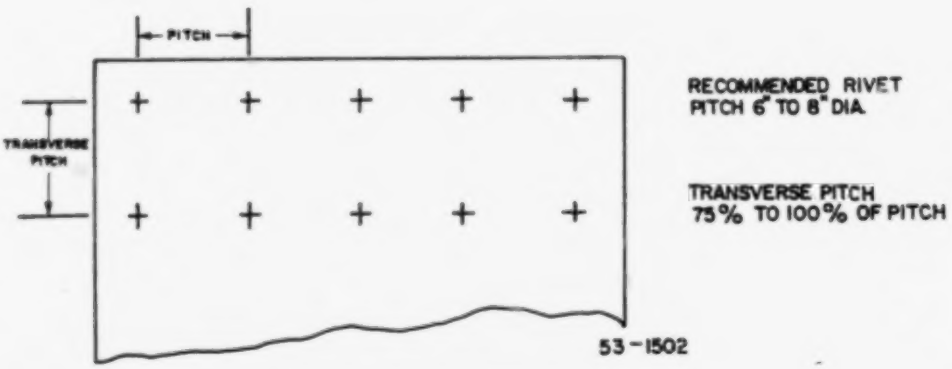


Figure 3-9. Rivet pitch and transverse pitch.

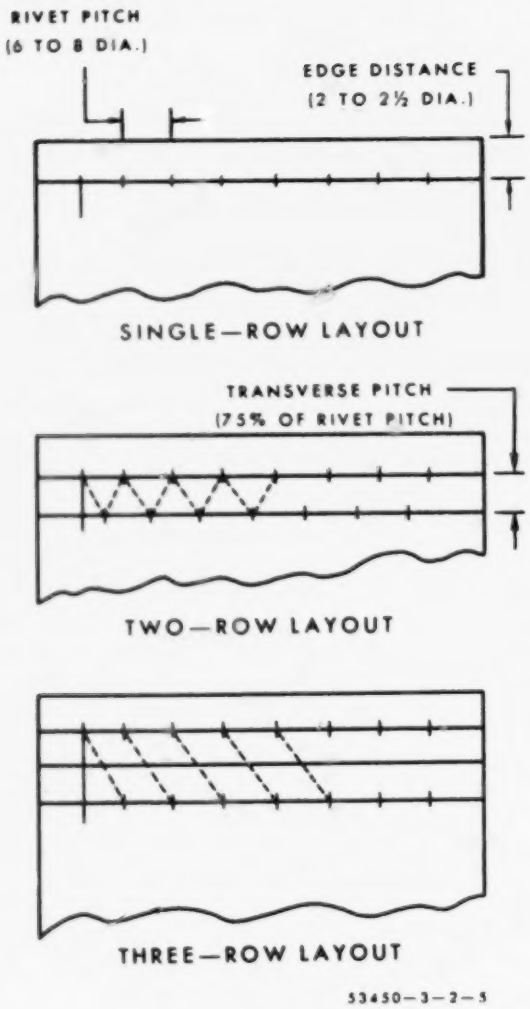


Figure 3-10. Rivet spacing.

apart if the rivets are in line (parallel to each other). The first rivet on each side of the joint should not be less than 2½ rivet diameters from the end of the sleeve.

Exercises (427):

1. Give the three items used to layout rivet spacing.

2. What physical feature of a solid rivet is used for calculations when spacing rivet locations?

3. If the maximum edge distance requirement is exceeded, what will most likely happen to the edge of a sheet of metal?

4. To avoid cracks from developing along the edge of a sheet of metal, what is the closest a rivet should be located to the edge?

5. What is necessary to calculate transverse pitch?

6. What is the average rivet pitch range?

7. How far apart should rivets be in splicing a damaged tube if the rivets are at a right angle to each other?

428. Given different shaped cutouts, point out limited procedures used to develop the required rivet layouts for a flush skin repairs.

The shape and location of a skin cutout will dictate the rivet layout used. There is no single specific layout pattern which will apply in all cases. Reference to the applicable -3 series technical order will provide you with the guidelines to follow in individual cases. Where specific guidelines are not given, the following layout procedures for various cutouts will meet requirements.

Circular Layout. A circular layout normally consist of two rows of rivets around the cutout and one row of rivets for the filler plate, as shown in figure 3-11. In making a layout, the rows outside the cutout are laid out first, then, after the repair parts have been fabricated, the inner row is laid out.

Outside layout procedures. Before any layout procedures can be accomplished, the center point of the cutout must be established. It is from the center part of teh cutout area that the locations of the outer rows of rivets is developed. The center part of the cutout is located by constructing perpendicular centerlines as shown in figure 3-12, part A. By taking a scrap piece of metal and taping it over the backside of the cutout area, you can draw the center point on the scrap piece of metal. Once you have accomplished this, you are ready to locate the locations of the outer rivet rows.

Using a pencil compass, place the metal point at the center point of the cutout area and draw a circle around the cutout area. This circle should be equal to the radius of the cutout area, plus the required edge distance, as shown in part B, of figure 3-12. Notice the point of the circle you have just drawn intersects the top centerline; this is the starting point for laying out the rivet locations. Accordingly, using dividers, layout the rivet locations, being sure that the recommended

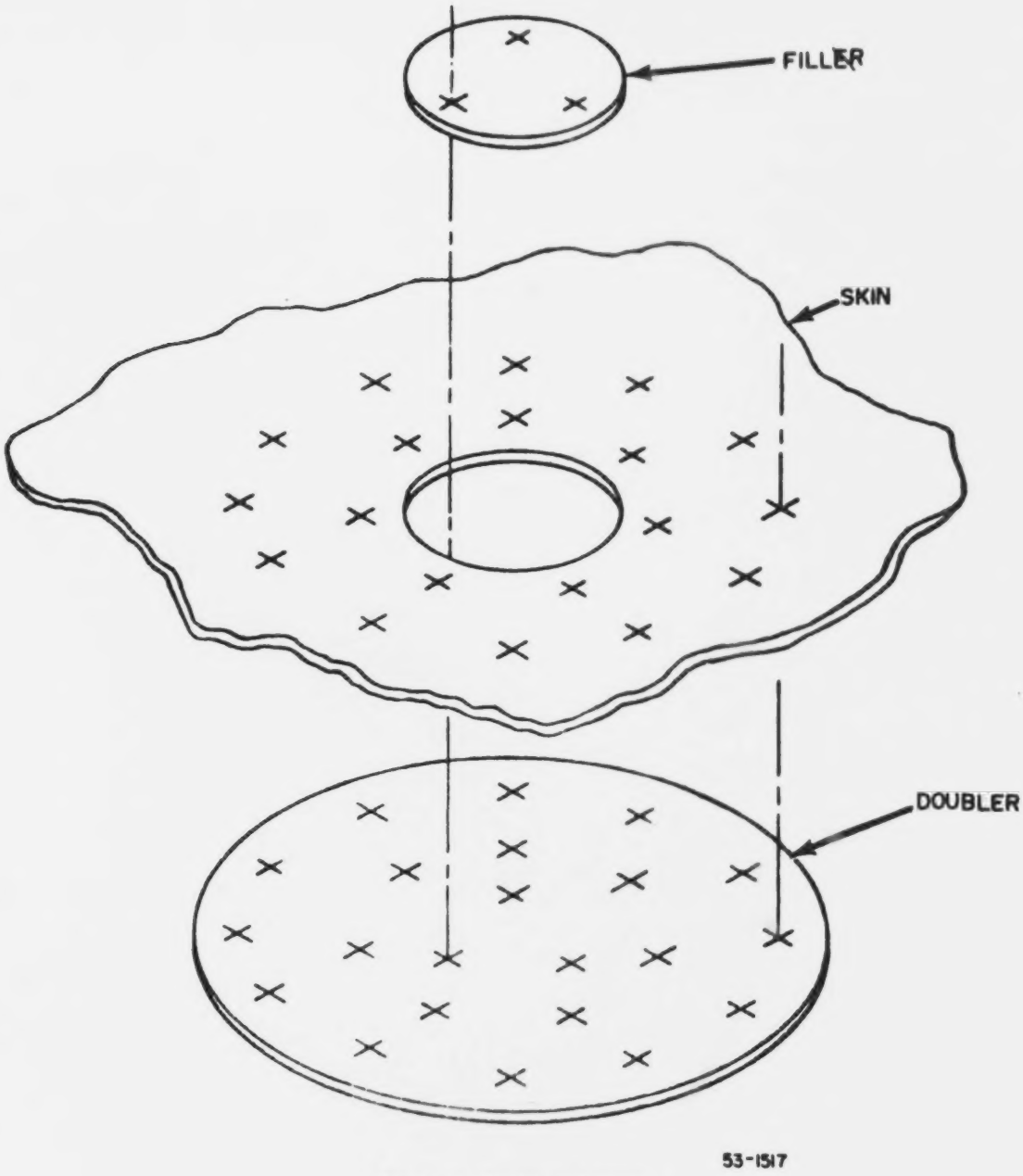


Figure 3-11. Circular patch layout.

rivet pitch should be used. Your layout should look similar to part C of figure 3-12. The second row's location is equal to the radius of the cutout, plus edge distance, plus 75° of the rivet pitch used to locate the rivets on the first row. Rivet locations—4 each—come where the outer circle intersects the perpendicular centerlines. Locate additional fasteners between these rivets, using the recommended rivet pitch. Your layout should look like part D, of figure 3-12.

Once all of the rivet locations have been located, you should be sure that they are center punched and pilot-drilled. Note that all rivet locations should be drilled only to the required size, with this being done just prior to the countersinking and rivet installation. This

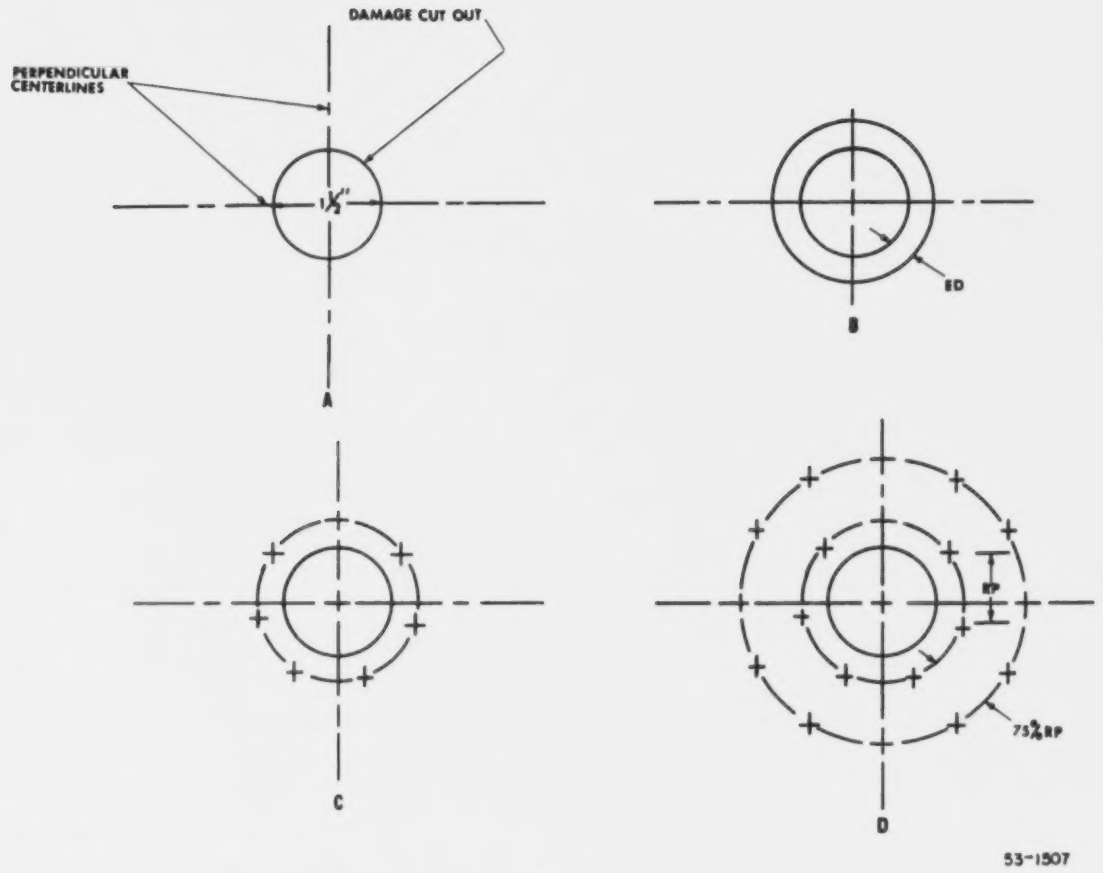


Figure 3-12. Circular patch layout procedures.

procedure reduces the possibility of elongating the rivet holes—a result which could cause misalignment of repair parts and oversized fastener holes.

Filler plate layout procedures. Only after the filler plate (plug) has been fabricated and fitted to the cutout, should the rivet layout be developed. Then, the rivet row must be edge distance from the edge, as shown in figure 3-13. The number of rivets required will depend upon the size of the cutout. But whatever the number, equally space the rivets, using the recommended rivet pitch. A quick way for you to locate the first rivet location is to extend the top centerline downward until it intersects the rivet row line on the filler plate.

Square Layout. The layout procedures for a square cutout differ from those used for a circular layout, because of the shape of the skin cutout. Figure 3-14 shows the type of rivet layout generally used for a square cutout. The layout sequence for the rivet locations is the same as that used for the circular layout—outside first, then the filler plate layout. Remember, here, that you should make all layout lines with a pencil, *not* a scriber.

Outside layout procedure. Proper outside layout procedure calls for the first row to be located edge distance from the cutout, as shown in figure 3-15. Draw the sides so that they intersect at each corner. The intersections of these lines indicate the locations

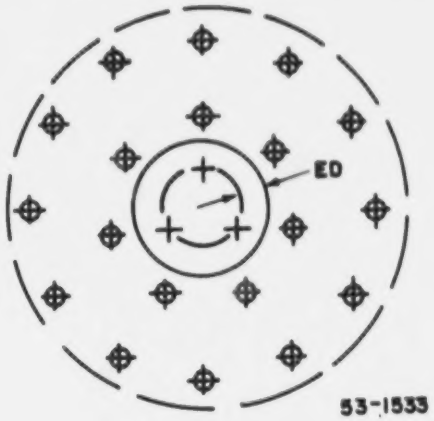


Figure 3-13. Circular patch filler plate layout procedures.

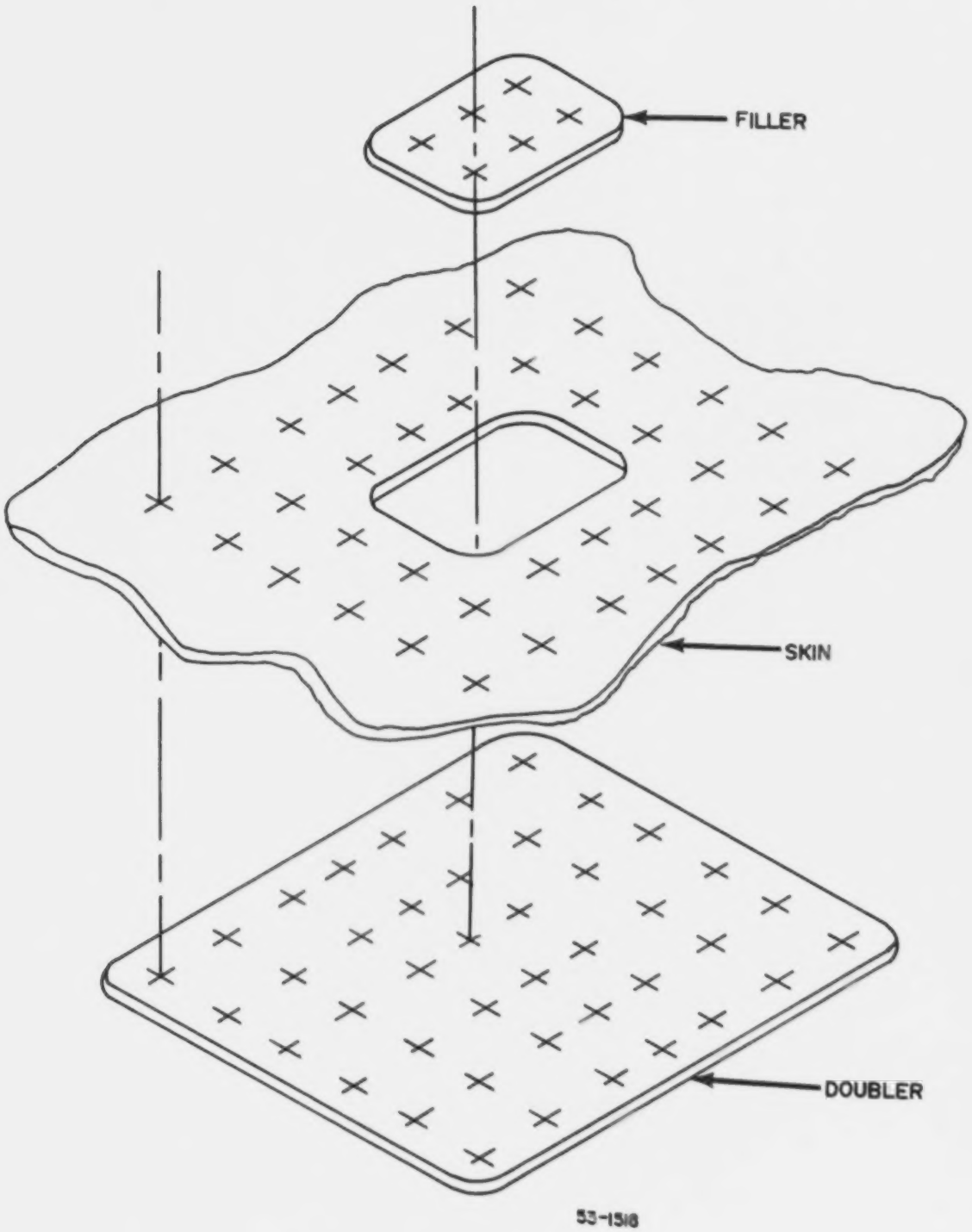


Figure 3-14. Square patch layout.

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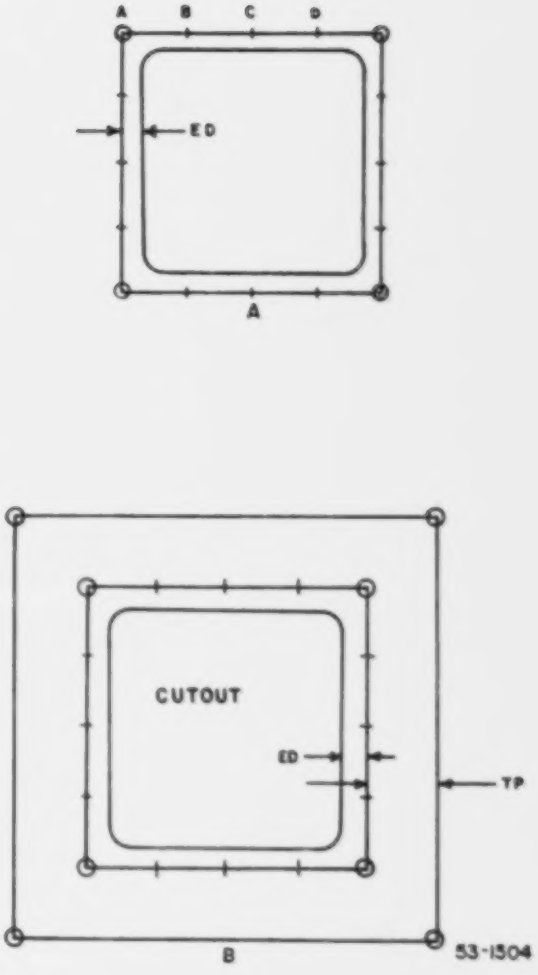


Figure 3-15. Square patch layout procedures.

of the four corner rivets of the inner row. You can then locate other rivet locations between each corner rivet. Place the second row 100 percent of the rivet pitch used for locating the rivets on the inner row. The corner rivets are found where the outer layout lines for the second row intersect, as shown in figure 3-15. Lay out additional rivets between the corner rivets. Since the transverse pitch and rivet pitch used on the inner row are identical, it is obvious that the locations of the rivet locations on the second row will be in line with the rivet locations on the inner row. You can use a straightedge to locate the rivet locations on the outer row. After you have completed the layout, center punch and pilot drill all locations.

Filler plate layout. The number of layout row needed in the filler will depend upon the size of the cutout and guidelines stated in the applicable -3 technical order. In any case, remember that the first row must be edge distance in from the edge of the filler pitch. If more than one row is required, the rules for transverse pitch apply.

Exercises (428):

1. What factors determine the design of the layout used for a flush skin repair?

2. When developing a layout pattern for a circular layout, where do the measurements for the location of the row of rivets originate?

3. What layout tool should you use to indicate rivet rows?

4. Why are fastener locations pilot drilled?

5. Besides assisting in locating the center point of the cutout area for circular cutouts, what other purpose do the centerlines serve?

6. State the sequence for developing a layout pattern.

7. When developing a layout pattern for a square cutout, how can you insure that the rivet location on the outer row are aligned with the rivet locations on the inner row?

8. What factors determine the number of rivets required in a filler plate?

9. What layout tool should you use to indicate layout lines?

10. Why is it recommended that you use a pair of dividers in spacing rivet locations?

429. Determine and state the sequence of events for developing a rivet layout over a substructural member for a flush skin repair.

When a substructural member is located within the cutout area, additional factors must be considered in developing the rivet layout.

Outside Layout Procedures. In keeping with the rule of developing the layout from the cutout area outward, locate the first row edge distance from the cutout. If the cutout has been made properly, the first existing rivet location on either side of the cutout should be the edge distance required, as figure 3-16 shows. Where the layout lines intersect are the corner locations, as shown in the bottom section of figure 3-16. This next step is very critical, and a mistake here could cause you additional repair work. So look at the bottom section of figure 3-16 again. You will see there that the lines used to show the location of the stringer are solid lines, not hidden lines, as used in the top section of figure 3-16. The reason for this is that you must indicate the width of the substructural member (in this

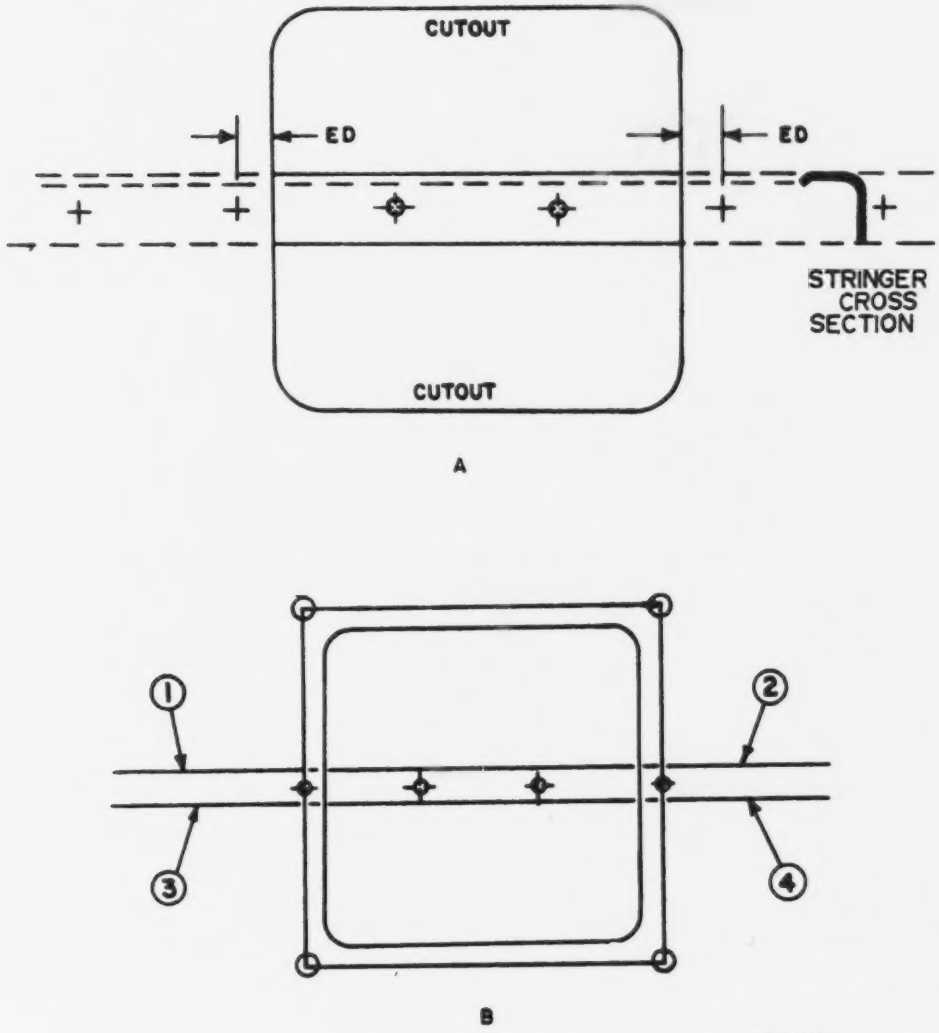


Figure 3-16. Layout procedures — over a substructural member, part A.

case a stringer) before you can proceed with rivet layout. By drawing pencil lines—number 1 & 2 and 3 & 4 in the bottom section of figure 3-16—on the skin surface, you'll be able to develop the edge distance needed for the rivets above and below the stringer. A common mistake is to measure edge distance from the existing rivet. This practice usually results in a rivet hole being drilled in the flange of stringer. Always measure from the outer edges of the substructural member, not the existing fasteners. The circled letters (A + B) in the top section of figure 3-17, indicate the rivet location at this point in the layout. The remaining rivet locations on the first row are spaced between the corner rivets and the rivet locations above and below the stringer.

Depending upon the location of the stringer, the number of rivet pitches used on the first row may vary. A general rule to follow in this case is to select a rivet pitch used on one side of the cutout, opposite the width of the substructural member for figuring the trans-

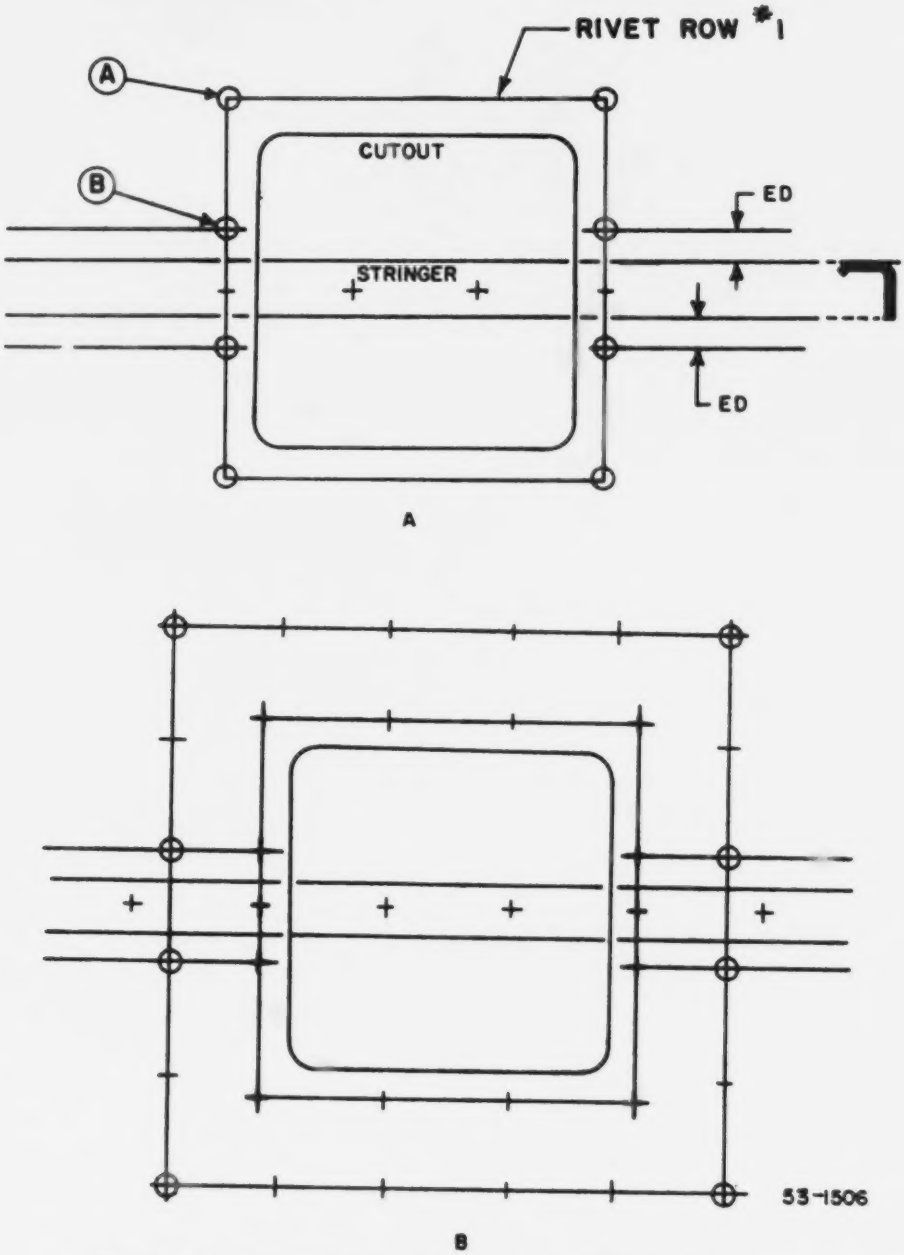


Figure 3-17. Layout procedures — over a substructural member, part B.

verse pitch. Once the layout line for the second row has been developed, space the rivet locations, using the same techniques as those you used for the inner row. Your completed layout should be very similar to one shown in the lower section of figure 3-17.

Filler Plate Layout Procedures. The main point for you to remember when laying out the filler plate is not to forget about the width of the stringer underneath. By positioning the filler plate in the cutout area, you connect the lines used to indicate the width of stringer on both sides of the cutout area. With this accomplished, follow the rules for rivet spacing to locate the required rivets.

Exercises (429):

1. If a skin cutout over a substructural member is made properly, would it be necessary to measure for edge distance when locating the first row of rivets outside the cutout area? Explain your answer briefly.
2. Besides the need to follow recommended spacing rules, what other factor must you consider when developing layout patterns for repairs over a substructural member?
3. What is the general rule to follow when you are developing the transverse pitch for fastener layout pattern over a substructural member?
4. What must be indicated on the filler plate for a repair over a substructural member before the layout pattern is started?

Step III, Fabrication and Installation of Repair Parts

THE FINAL STEPS in completing a repair are the fabrication and installation of the repair parts. The first section of this chapter will concern the techniques used to fabricate the necessary repair parts. The last section will get into the installation techniques used for installing the repair parts. This last step is very important, because all of the work you have accomplished prior to this step can come to nothing if you make a mistake now.

4-1. Fabrication of Repair Parts

Prior to this point in the repair process, you should have had an idea of the number of repairs necessary to restore the damaged area to its' original strength and configuration. How you go about fabricating the required parts will depend upon a number of factors. Obviously, you will have to change your repair techniques from repair to repair, for there is no set rule to follow when fabricating repair parts. Recognizing this, the following techniques are designed to save you time and to insure that properly fabricated repair parts are produced.

430. Give specific factors and procedures related to fabricating repair parts necessary for a flush skin repair.

The basic parts necessary for a flush skin repair consist of a filler and doubler. Each has a specific function to serve. The filler returns the skin area to its original contour, while the doubler restores the load-carrying abilities to the skin area. We will approach the techniques for fabricating the filler and doubler for a flush skin repair from two directions—an open and blind area.

Doubler. The preferred sequence of fabricating flush skin repair parts is to fabricate the doubler first. By doing this, the doubler can be placed into position when the filler is fitted to the cutout area.

Open area fabrication techniques. An open area exists where access to the backside of the cutout area is open. In such cases, fabrication of the doubler is relatively simple.

The following steps outline the techniques to employ in this situation:

a. Construct the centerline on the skin area, indicating the center of the cutout area.

b. Select the material for the doubler. The material must be one gage thicker than the skin area, with the

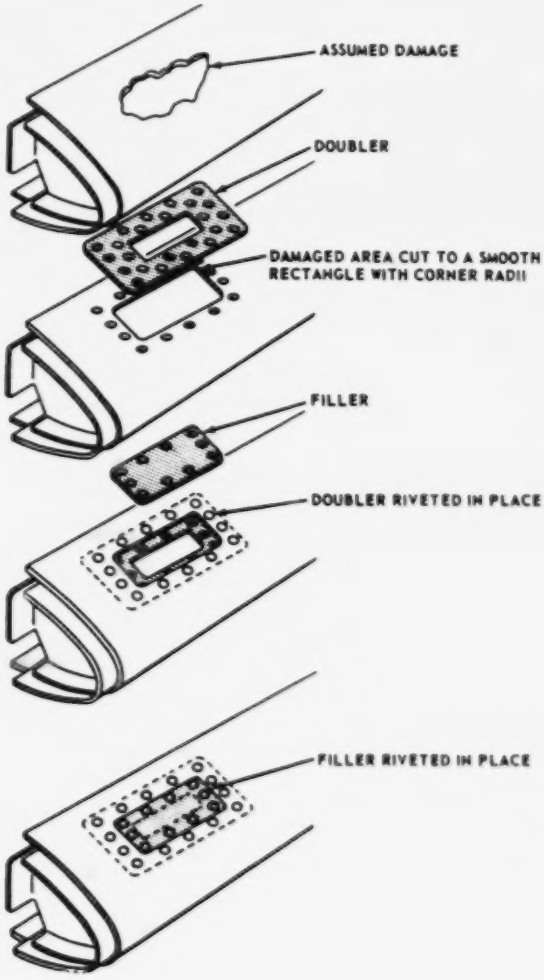


Figure 4-1. Flush repair — single doubler.

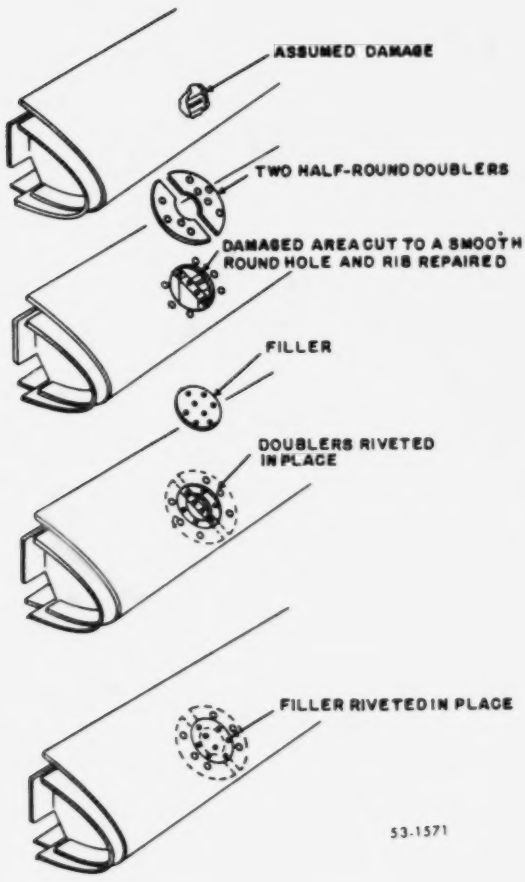


Figure 4-2. Flush repair — two doublers.

temper condition, and, at this time, larger than the overall length of cutout and rivet layout (both sides) combined.

c. Construct centerlines on the doubler material.

d. Position the doubler material behind the cutout, aligning the centerline on the doubler with those on the skin surface. This procedure insures that the needed material has been positioned on both sides of the cutout area.

e. With the doubler material in place behind the cutout, pilot drill through the fastener layout on the skin. Use an ample amount of Cleco fasteners during the drilling process to eliminate misalignment of the doubler.

f. After all the fastener holes have been pilot drilled, remove the doubler material from the backside. As an aid in the realignment of the doubler (for later repair procedures), place alignment marks on the doubler prior to removing it. You can accomplish this by placing a pencil mark on the edge of the skin cutout, while placing a corresponding mark on the doubler.

g. With the doubler material removed, add the required edge distance out from the last row of fasteners. If the shape of the doubler is other than circular, radius the corners equal to the edge distance used in the fastener layout. Your doubler is completed at this time.

Blind area fabrication techniques. In cases where access to the back side of the skin cutout is impossible, blind area fabrication techniques must be followed. The size and shape of the cutout will have a bearing on how you fabricate the doubler. When the size of skin cutout is large enough, a single doubler is used, as shown in figure 4-1. If the size of the skin cutout is too small for a one piece doubler, you must split the doubler into two parts, as figure 4-2 shows. For a circular skin cutout, a single doubler may be used after a hole has been punched in the center and a cut has been made from the outer edge to the hole. This proce-

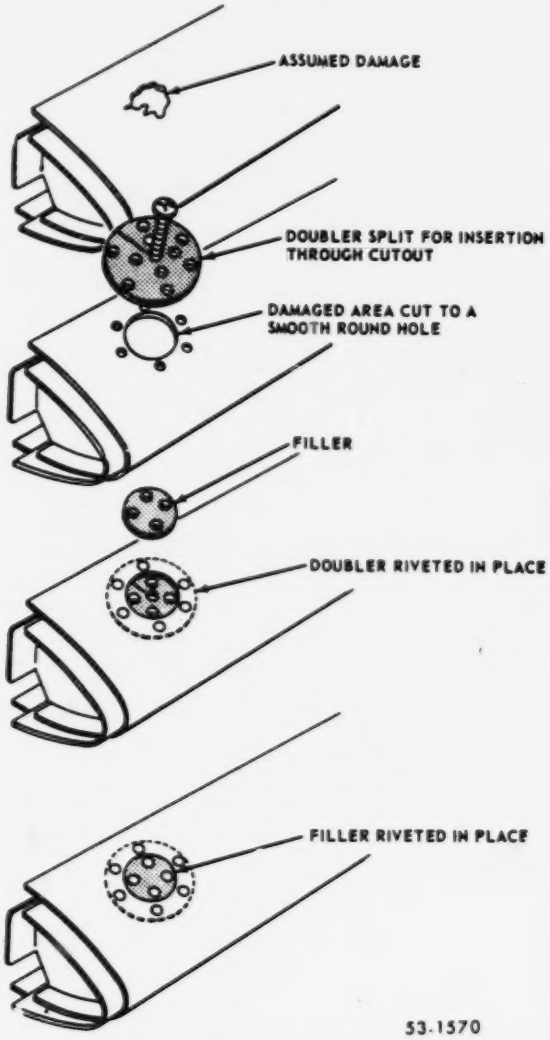


Figure 4-3. Flush repair - split doublers.

dure permits the doubler to be "turned" into the cutout area, as shown in figure 4-3.

When you must split a doubler, make the cut on the doubler between the fastener locations, ensuring that the proper edge distance is maintained. This practice also holds true when cutting a doubler for insertion behind a circular cutout. No matter which method you select to use, once you are able to position the doubler material behind the fastener layout, follow the procedures covered previously for an open area. Employ special precautions to insure proper alignment of the repair when working in a blind area. Also, proper techniques must be used to eliminate the possibility of repair parts falling into the blind area.

Filler Plate. The filler is next fabricated, using the following sequence:

a. Select a filler material equal in thickness and temper condition to the skin area.

b. With a piece of material larger than needed, position the filler material behind the cutout area. Holding it into place, scribe around the cutout area, making sure that the scribe marks are visible. Before removing the material, place alignment marks on the filler layout.

c. Remove the metal and, cutting along the scribe line, remove the excess material.

d. Cleco the doubler in place, assuring that the alignment marks are aligned.

e. Position the filler in the cutout aligning the alignment marks, and check the amount of clearance between the filler and skin cutout. Remove the filler if additional filing is necessary. Repeat this procedure until a clearance of 1/32 of an inch is maintained between the filler and skin cutout.

In blind areas, you may find it easier if you fabricate the filler prior to making the skin cutout. In such a case, make sure that all of the damage will fall within the overall dimensions of the filler. The corner radii of the filler will be the same as those needed for the skin cutout. Once the filler is fabricated, it can be used as a template to trace the outline of the filler over the damaged area. When using this technique, you must take special care when making the skin cutout. Any deviations from the outline will require that a new filler plate be fabricated.

At this time the parts for a flush patch are completed. In areas where a substructural member is within the cutout area, you must modify these procedures somewhat. Still, if you follow the basic techniques we have discussed, you should be able to make the necessary modifications with little, if any, problems.

Exercises (430):

1. When fabricating the doubler for a flush patch in an open area, why are alignment lines placed on the doubler and skin surfaces?
2. What procedure is used to locate fastener holes on the doubler when a flush repair is made in an open area?
3. What factors determine the number of doublers required when a flush repair is made in a blind area?
4. Describe the procedures used to develop the outline of a filler plate for a flush patch in an open area.
5. Fabricating a filler plate before making the skin cutout is usually accomplished for what type of repair areas?

431. Clarify specific correct factors to check, problems created, and methods and procedures followed in fabricating repair parts for a nonflush repair.

A nonflush repair is used as a reinforcement plate for a damaged area. It can be placed over a prepared cutout, small dents, cracks, etc., where aerodynamics smoothness is not critical and when the installation of a flush patch would be impractical because of the structure of the area. Certain portions of chemmilled and machine milled skins are types of areas where a flush patch would be impossible or extremely difficult to install properly. Always consult the applicable -3 technical order before installing a nonflush patch.

The fastener layout procedures used to develop rivet locations for a nonflush skin repair can be accomplished in two ways: (1) on the damaged part or (2) on the patch plate itself. Which of these ways you select will dictate the techniques you will follow in fabricating the patch plate. The following paragraphs provide details of each of these techniques.

Layout on the Damaged Part. In an open area, make the layout the part. Here the layout procedures are the same as those you used for developing a flush patch rivet pattern. Also, the techniques used to fabricate the patch plate are the same as those you used to fabricate a doubler for a flush skin repair in an open area. But here, the material is placed on the outside of the skin area, not on the inside, after being trimmed to the proper dimensions.

In repair situations, where a nonflush repair is installed in a blind area containing existing fastener locations, laying out the fastener layout on the part itself creates two problems. The first is the locating of

the holes in the patch plate; whereas the second is the centering of the patch plate over the cutout area for proper material allowances on both sides of the damaged area. You can overcome the first problem by using special methods of locating blind holes.

Hole finder method. You will find use of the hole finder to be the fastest, most accurate method of locating blind fastener holes. Hole finders may be made of various materials and in special shapes and sizes when the conditions of the job do not permit the use of a hole finder, such as shown in figure 4-4. Although a temporary or one-time-use tool may be fabricated in a few minutes from any scrap of hardened aluminum alloy and a rivet of the desired size, a complete set of well-made tools, similar to the one shown in figure 4-4, is desirable. Such a complete set will consist of a hole finder for each size sheet metal fastener used, usually 3/32–5/16 of an inch. When blind holes are being located with a hole finder, it is important that you do not allow the material being marked or pilot drilled to move. Fasten the patch plate to the part with Cleco fasteners and move them as necessary as the marking or drilling progresses.

Scale methods of locating blind holes. In the lower half of figure 4-4 are illustrated two methods of locating blind holes, using a scale. Take a few minutes to run through the procedures given for both methods on figure 4-4.

Template method. In certain work situations it may be necessary for you to make a template of the rivet layout. You can use a thin piece of transparent plastic for this purpose. As holes are drilled through the plastic, install Clecos to keep the plastic from moving. After the holes have been drilled, transfer the holes to the patch plate.

You can overcome the second problem of material allowance by locating alignment lines on both the part being repaired and the patch plate. Remember that alignment lines marked in the damaged part must be extended far enough outward so that the alignment lines on the patch plate can be matched with them. This procedure will provide the necessary overlap on both sides of the damaged area for the fastener pattern holes required in the patch plate.

Layout on the Patch Plate. Seldom is the development of a fastener layout on the patch plate done when an open area is repaired. It is easier to use rivet pattern on the part itself to drill the holes into the patch plate. After this, it is a simple matter of trimming the patch plate to the correct size before its installation.

In blind areas containing no existing fasteners, the required fastener pattern can be developed on the patch plate itself. The plate is, in turn, used as a drilling template for locating the fastener holes on the damaged part. When you use this method, you must mark alignment lines on both the damaged part and the patch plate. The reason why this is necessary is that the location of the cutout or the area of the damage must be indicated on the patch plate when the fastener layout is developed. After all holes have been drilled, trim the patch plate to the required size, and the patch plate will be ready for installation.

Exercises (431):

1. What must you check before installing a nonflush repair on an aircraft?

2. What factor determines the fabrication sequence for a nonflush patch plate?

3. What two problems are created when the required fastener layout for a nonflush skin repair in a blind area is developed on the skin surface?

4. Which hole-finding method is most accurate?

5. What must be indicated on the patch plate for a nonflush repair when the fastener layout is developed on the patch plate?

432. Cite main factors to consider and methods preferred in removing and fabricating a damaged skin panel, define "back drilling," and tell why certain screws are not recommended for temporary holding purposes.

Skin Replacement. Sometimes damage to the metal skin is so extensive that an entire panel must be replaced. Also, an excessive number of patches or minor repairs to a section or area may require replacement of the entire panel.

As in all other forms of repair, here your first step is to inspect the damaged area thoroughly to determine the extent of damage. Inspect internal structure for damage or signs of strain. If you find such members bent, fractured, or wrinkled, they must be replaced or repaired. Inspect all rivets in the area for signs of failure, since they may be sheared considerably without visible external evidences of such a condition. Accordingly, drill out rivets at various points in the damaged area and examine them for signs of shear failure.

During your inspection, note carefully all unusual riveting problems which render riveting difficult or which make replacement impossible. Any fixtures

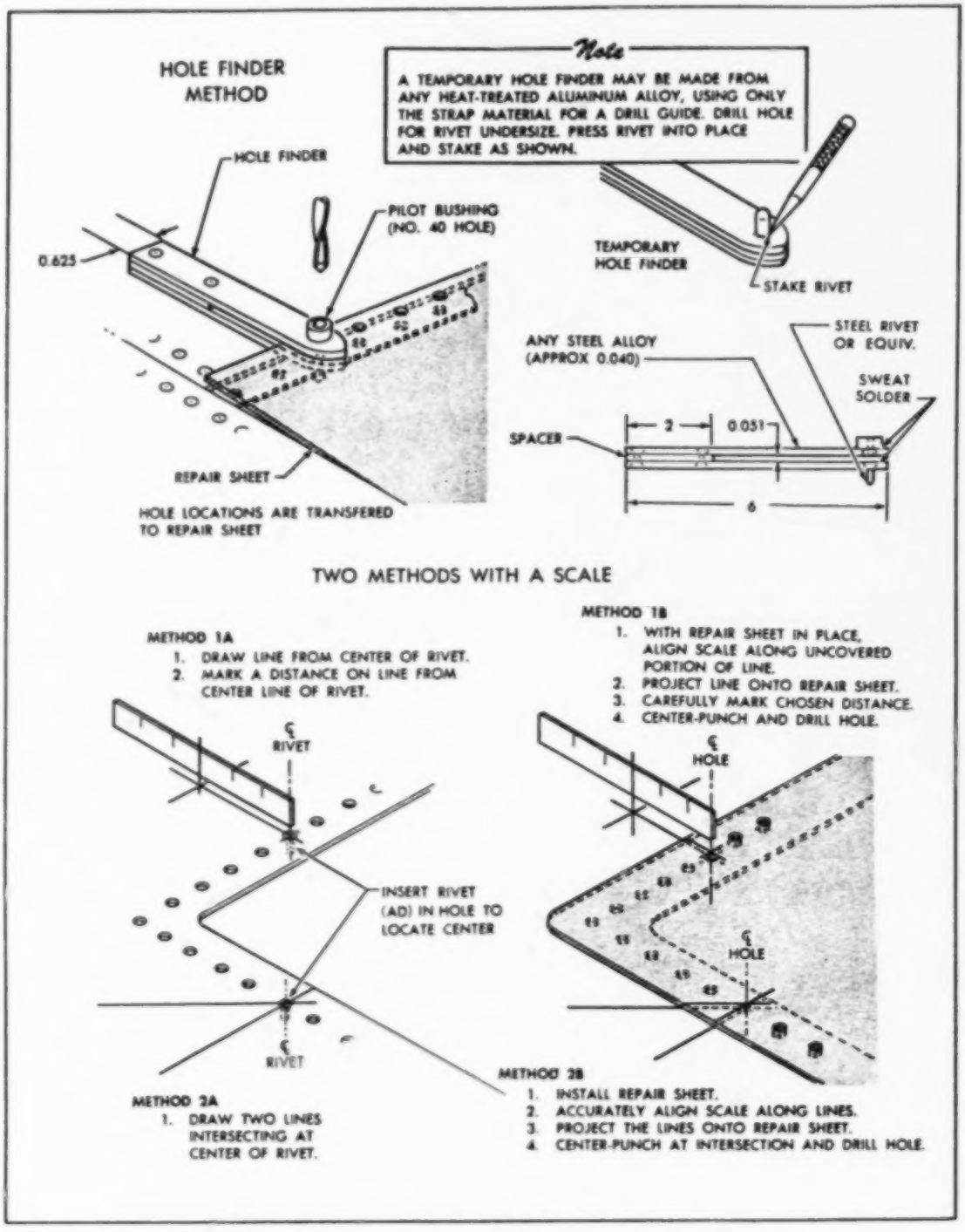

HOLE FINDER METHOD
Note
A TEMPORARY HOLE FINDER MAY BE MADE FROM ANY HEAT-TREATED ALUMINUM ALLOY, USING ONLY THE STRAP MATERIAL FOR A DRILL GUIDE. DRILL HOLE FOR RIVET UNDERSIZE. PRESS RIVET INTO PLACE AND STAKE AS SHOWN.
HOLE FINDER
PILOT BUSHING (NO. 40 HOLE)
0.625
REPAIR SHEET
HOLE LOCATIONS ARE TRANSFERED TO REPAIR SHEET
TEMPORARY HOLE FINDER
STAKE RIVET
ANY STEEL ALLOY (APPROX 0.040)
STEEL RIVET OR EQUIV.
SWEAT SOLDER
SPACER
2
0.051
6
TWO METHODS WITH A SCALE
METHOD 1A
1. DRAW LINE FROM CENTER OF RIVET.
2. MARK A DISTANCE ON LINE FROM CENTER LINE OF RIVET.
℄ RIVET
INSERT RIVET (AD) IN HOLE TO LOCATE CENTER
℄ RIVET
METHOD 2A
1. DRAW TWO LINES INTERSECTING AT CENTER OF RIVET.
METHOD 1B
1. WITH REPAIR SHEET IN PLACE, ALIGN SCALE ALONG UNCOVERED PORTION OF LINE.
2. PROJECT LINE ONTO REPAIR SHEET.
3. CAREFULLY MARK CHOSEN DISTANCE.
4. CENTER-PUNCH AND DRILL HOLE.
℄ HOLE
℄ HOLE
METHOD 2B
1. INSTALL REPAIR SHEET.
2. ACCURATELY ALIGN SCALE ALONG LINES.
3. PROJECT THE LINES ONTO REPAIR SHEET.
4. CENTER-PUNCH AT INTERSECTION AND DRILL HOLE.

Figure 4-4. Methods of locating blind holes.

which might hinder riveting and/or prevent the use of straight bucking bars will be apparent in a thorough inspection. You will also find places where flanges of reinforcing members, or the intersection of stringers, longerons and formers, frames, or rings make the bucking of rivets very difficult. You can solve this latter problem by designing and making bucking bars to suit these particular situations.

Be careful to avoid mutilating the damaged skin in the process of removal. Why? Because in most cases you can use it as a template for the layout and drilling of holes in the new piece of skin.

The rivet holes in stringers, longerons, bulkheads, formers, frames, rings, and other internal members must be kept in the best condition possible. If any of these members are loosened by the removal of rivets, mark their locations so that they can be returned to their original positions when the repair has been completed.

Reference should be made to the applicable skin panel diagram in the manual for the specific aircraft involved for the gage and alloy of material to be used for the replacement panel. You may determine the size and shape of the panel in either of two ways: (1) measure the dimensions during the inspection or (2) use the old skin as a template for the layout of the sheet and the location of the holes. The latter method is the preferable more accurate one. However, regardless of the procedure used, the new sheet must be large enough to replace the damaged area and may be cut with an allowance of 1 to 2 inches of material outside the rivet holes.

If the old sheet is not too badly damaged, you should flatten it out and use it as a template. The new sheet, having been cut approximately 1 inch larger than the old, should then be drilled near the center of the sheet, using the holes in the old sheet as a guide. Then fasten the two sheets together with sheet metal fasteners. The use of shet metal screws is not recommended, because they injure the edges of the rivet holes. The drilling should proceed from the center to the outside of the sheet, with you inserting sheet metal fasteners at frequent intervals.

If it turns out to be impossible for you to use the old sheet as a template, drill the holes in the new sheet from the inside of the structure, using the holes in the reinforcing members as guides, drilling and inserting fasteners just as already described. This method is called back-drilling. Before placing the new sheet on the framework to drill the holes, make certain that the reinforcing members are aligned and flush at the points at which they intersect; otherwise the holes in the new sheet will not be aligned accurately. For the same reason, the new sheet should have the same contour as the gold one before you drill the rivet holes.

In duplicating holes from reinforcing members to skin, exercise extreme care, or both the frame and the skin will be ruined. After all, since most bulkheads, ribs, and stringers depend upon the skin for some of their rigidity, they can easily be forced out of alignment in the drilling process. You must hold the skin firmly against the framework, or the pressure from the drilling will force it away from the frame and cause the holes to be out of alignment. This possibility may be overcome by placing a block of wood against the skin and holding it firmly while your drilling progresses. Also, make sure that the drill is held at a 90° angle to the skin at all times, or the holes will be elongated and out of alignment. When drilling through anchor nuts, use a smaller pilot drill first. Be careful to avoid damaging the anchor nut threads; then enlarge the pilot holes to the proper size.

It may be necessary for you to use an angle attachment or a flexible shaft drill in places where it is impossible for you to insert a straight drill. In the event that *neither* type can be inserted, you can mark the new section carefully with a soft pencil inserted through the holes in the old section. Another method of marking the location of the new holes is to use a transfer or prick punch. Center the punch in the old hole, then hammer lightly on the outside of the sheet with a mallet. The result should be a mark which will serve to locate the hole in the new sheet.

After all the holes have been drilled, see that the temporary fasteners are taken out and the sheet is removed from the framework. Remove burrs left by drilling from both sides of all holes in the skin, stringers, and rib flanges. You can deburr with a few light turns of a countersink. In this way, particles of metal left around the edges of the drilled holes are eliminated. If they were not removed, the joint will not be tight, and rivets might expand or flash between the parts being riveted.

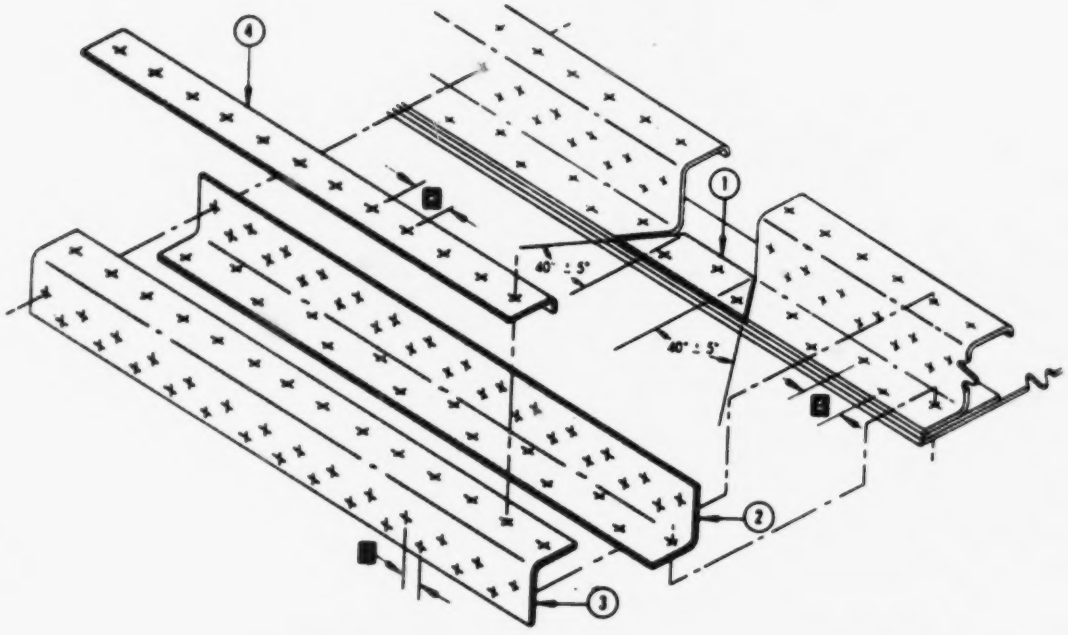
Exercises (432):

1. What factors must you consider when you are determining whether a skin panel should be repaired or replaced?

2. Which method is preferred during development of the size and shape of the replacement skin panel?

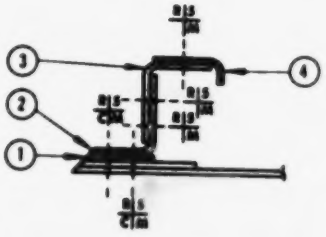
3. Define the term "back-drilling."

4. Why are sheet metal screws not recommended for use as temporary holding devices?



REPAIR MATERIAL

1	1	FILLER .040 AISI TYPE 17-7PH CRES, HT TR 180,000 TO 200,000 PSI
2	1	ANGLE .032 AISI TYPE 17-7PH CRES, HT TR 180,000 TO 200,000 PSI
3	1	ANGLE .032 AISI TYPE 17-7PH CRES, HT TR 180,000 TO 200,000 PSI
4	1	ANGLE STRAP .032 AISI TYPE 17-7PH CRES, HT TR 180,000 TO 200,000 PSI



SECTION THROUGH REPAIR

NOTE

THIS REPAIR APPLICABLE TO UPPER LONGERON AFT OF STATION 171.82

FOR SKIN REPAIR SEE FIGURE 10-1

■ ORIGINAL SPACING

■ MATCH ORIGINAL SPACING

■ USE ONE-HALF ORIGINAL SPACING

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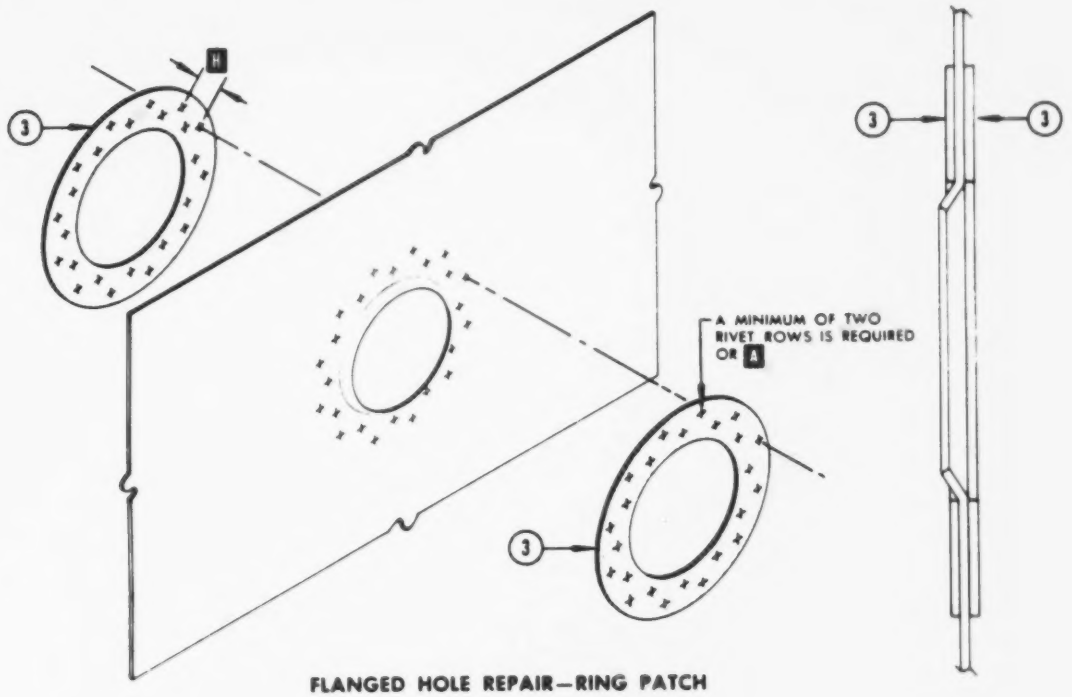
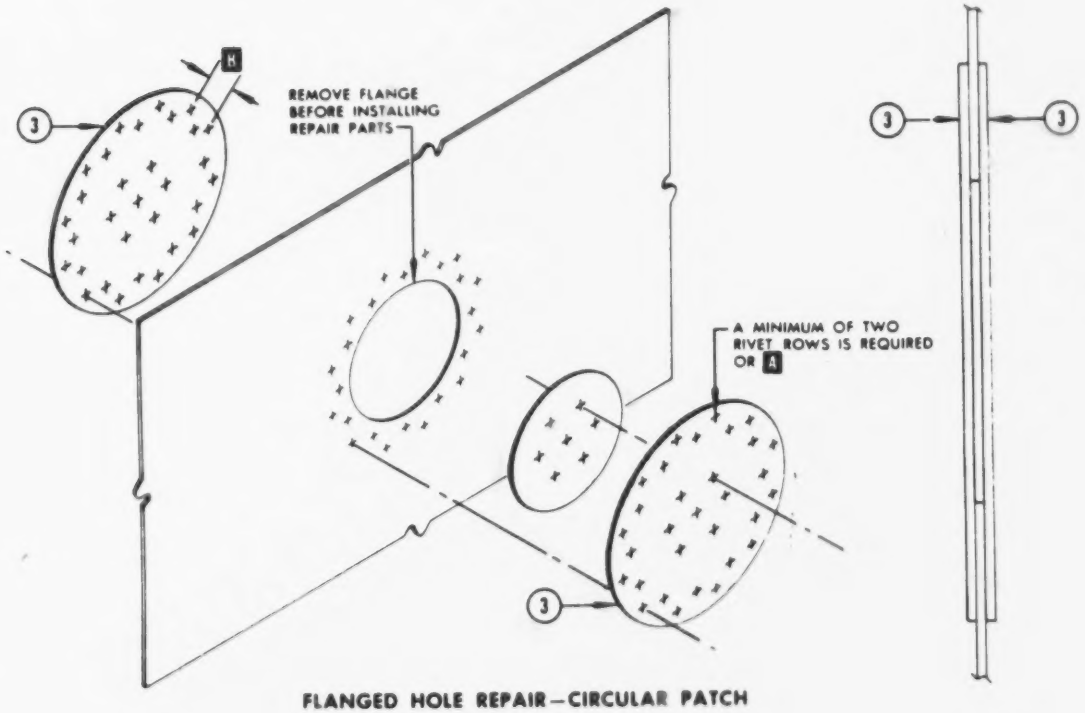
Figure 4-5. Longeron repair.



FLANGED HOLE REPAIR—RING PATCH



FLANGED HOLE REPAIR—CIRCULAR PATCH

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Figure 4-6. Typical web repair.

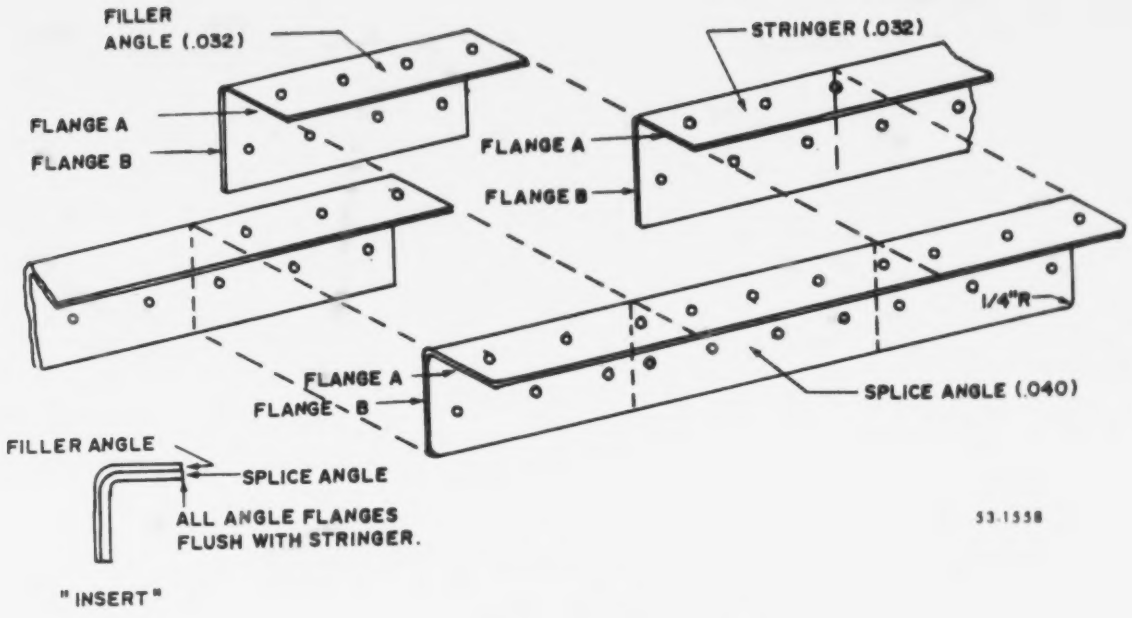

Figure 4-7. Stringer repair.

433. Supply selected features, measurements, procedures, and factors involved in a substructural repair and compare stringer splice and original stringer bend radii.

The number and shape of repair parts required in making a substructural repair will vary according to the damage incurred and the original shape of the part. Figure 4-5 and 4-6 illustrate just two possible variations of substructural repairs you might have to accomplish. Figure 4-5 shows a repair involving the use of reinforcement angles. Figure 4-6 illustrated two methods of repairing a web section of a rib. In our discussion, the fabrication of the repair parts necessary to repair a 90° stringer will be covered. Figure 4-7, points out the repair parts needed in making an insertion type repair for a stringer.

Stringer Filler. The stringer filler must match the original stringer in material composition, thickness, and dimensions. The fabrication procedures that you will use in making the repair part are directly related to the process used to fabricate the original stringer, which was either formed or extruded. Procedures for duplication on extruded parts have been discussed in Volume 2 of this CDC, so only the procedures for fabricating the repair parts for a formed stringer will be covered at this time.

The overall dimensions for the stringer filler should be taken from the damaged sections removed when the cutout was made. The width of flanges and bend radii are the key measurements needed. If the original stringer has only two flanges, calculations for set back and bend allowance are unnecessary. However, in situations where the stringer has a third flange —usually a small return flange—calculations are required. This procedure is necessary because of the two bend radii that must be matched.

Since the stringer shown in figure 4-7 has only two flanges, we will cover only those techniques which required no calculation. Follow these general guidelines:

(1) Using a scrap piece of metal, adjust the cornice brake so that the bend radius matches the original bend radius of the stringer. Too large a bend radius will lead to problems later when rivets are installed in the flanges.

(2) Once the proper bend radius is obtained, bend a piece of metal 1/32 of an inch shorter in length than the cutout and with flanges wider than needed.

(3) Position the filler inside the cutout, allowing 1/64 of an inch clearance between each end of the stringer filler and stub ends of the stringer. This procedure eliminates any possibility of stress developing from contact between the parts.

(4) Obtain the required width of the flanges by scribing a cut line on the flanges. Accomplish this by positioning the stringer filler in the cutout, making sure the bend radii are aligned, and scribing a cut line between both ends of the stringers. Use this technique for both flanges.

(5) Remove the stringer fill and cut the flanges to the correct width indicated by the scribed cut lines. At this time the Stringer filler is completed.

Stringer Splice Angle. The stringer splice angle is normally positioned inside the original stringer, as illustrated in the lower left-hand position of figure 4-7. The bend radius of the stringer splice angle will be smaller than that used for the stringer filler; so the cornice brake must be readjusted. As for the overall length of the stringer splice angle, determine this by the amount of overlap required on each side of the cutout area. Generally, three original rivets plus edge distance, on both sides of cutout area, are used to determine the length. The stringer splice angle must be one gage heavier than the original stringer.

The procedures for fabricating the splice are as follows:

(1) After the correct bend radius has been developed, bend a piece of metal longer than required, having wider flanges than necessary.

(2) Position the stringer splice angle in place over the cutout area, making sure that enough overlap is allowed on each side of cutout area. Drill through the existing fastener holes covered by the stringer splice angle. Install Cleco fasteners.

(3) With the stringer splice angle Celcoed in place, scribe cut lines for the proper width required on each of the flanges.

(4). Remove the stringer splice angle from the original stringer. Trim the flanges to their required width. Also, from the last (outer most) fastener hole drilled, measure out the required edge distance. This step develops the overall length of the stringer splice angle.

(5) Cut the stringer splice angle to the required length and radius for the ends of both flanges. In most cases, the size of the radius used is equal to the edge distance used for the fastener layout. However, when this practice would remove too much material from the flanges, a smaller corner radius measurement may be used.

Exercises (433):

1. When it is necessary to repair a substructural member, what feature of the part being repaired influences the methods of fabricating the repair parts?

2. What are the key measurements needed to fabricate a stringer filler?

3. How should the bend radius of the stringer splice compare to the bend radius on the original stringer?

4. When using the noncalculating method to fabricate a 90° stringer filler, how is the proper width of the flange located?

5. What factors determine the overall length of a stringer splice?

434. Cite factors, recommendations, similarities, and determinants to consider when making a combination substructural member and skin repair, and compute the length of a fabricated stringer splice in a given situation.

Up to this point, we have discussed the techniques to use in making a flush skin repair and a substructural member repair as separate repairs. In contrast, a "combination repair" is one required when both the outer skin and a substructural member have been damaged; i.e., it is a required repair involving repairing both of them at the same time. Since it would be repetitious and time consuming to repeat the techniques used to fabricate the individual parts, only key points you need to remember will be high-lighted when the repairs are combined together.

Cutout Procedures. The cutouts on the skin and substructural member can be of either the same size or of different sizes. The amount of damage, plus the location of existing fasteners, will determine the cutouts for each. In work situations where the cutouts are of different sizes, always provide protection to other members — whether it is the skin or the substructural member — when you are making the cutouts.

Fastener Layout Procedures. Figure 4-8 illustrates the complete fastener layout required when making a combination repair involving a stringer and skin.

Key points for you to remember when making this fastener layout are these:

(1) Locate the first fastener on either side of the substructural member edge distance from the edge of the substructural member, *not* from the center of existing fasteners.

(2) Employ the rivet pitch for existing fasteners in the substructural member to obtain transverse pitch in the fastener layout for the doubler.

(3) First, pilot drill all fastener holes. Drill the fastener holes to the proper size just prior to installing the required fasteners.

(4) Use cleco fasteners to eliminate misalignment of repair parts.

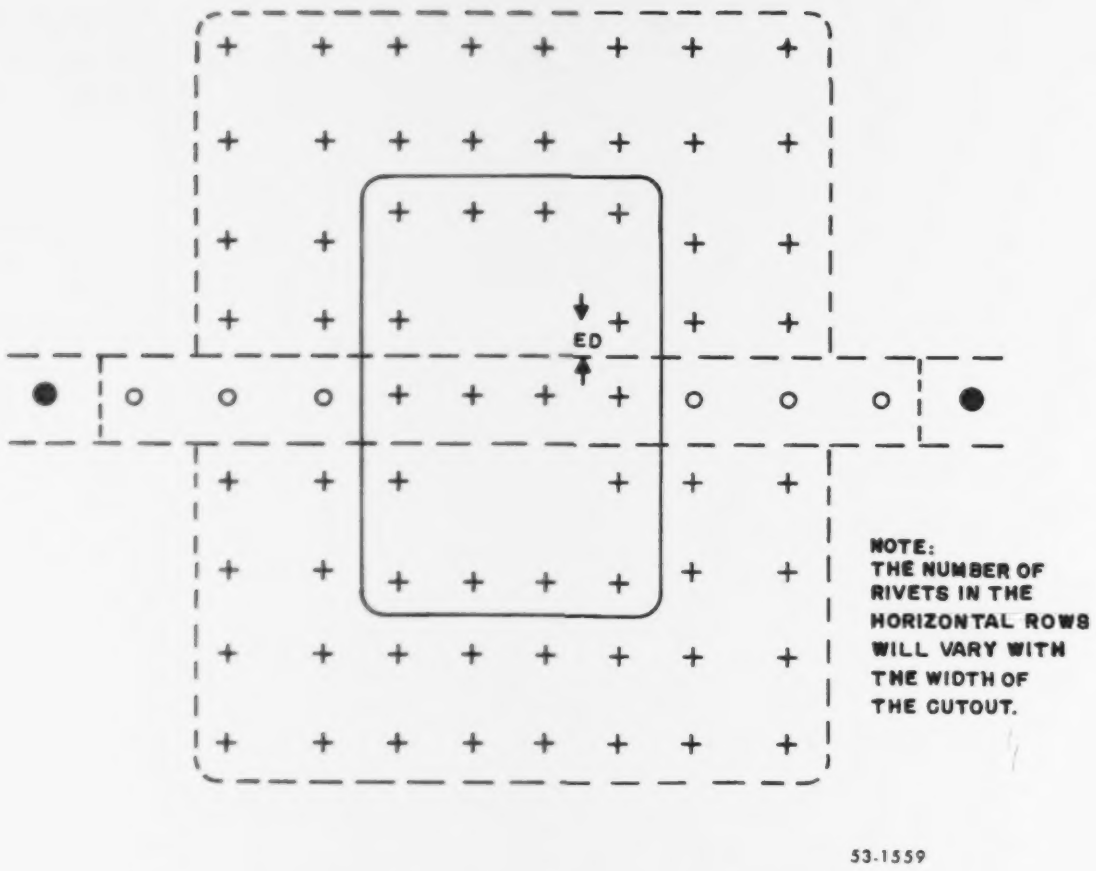

Figure 4-8. Typical fastener layout — combination repair.

(5) Have the same fastener locations as used on the vertical flange on the fastener layout on the horizontal flange (not shown in the fig. 4-8) of the stringer splice.

Fabrication Procedures. Key points for you to remember when fabricating the repair parts are:

(1) Match the skin filler to the original skin in thickness, temper, material composition, and contour.

(2) Have skin doublers one gage thicker than the skin thickness and of the same material composition, temper, and contour as that of the skin area, positioning the doublers' alignment, as shown in figure 4-9.

(3) Match the stringer filler—if it is a formed stringer being repaired—of the same thickness, shape, material composition, and temper as the original stringer.

(4) Follow the procedures outlined for extruded stringers, in the applicable -3 technical order for fabricating a required filler replacement.

(5) Make the stringer splice one gage thicker than the original stringer and position it inside the original stringer, fitting as closely as possible.

(6) Determine the length of the stringer splice by the spacing of existing fastener locations in the original stringer on both sides of the cutout area, as shown in figure 4-10.

(7) Keep the width of the flanges on the stringer splice equal to the flanges of the original stringer.

Exercises (434):

1. What factors determine the size of cutouts when making a combination repair?

2. Why is it recommended that Cleco fasteners be used in drilling the repair parts for a combination repair?

3. How should the skin filler match the original skin?

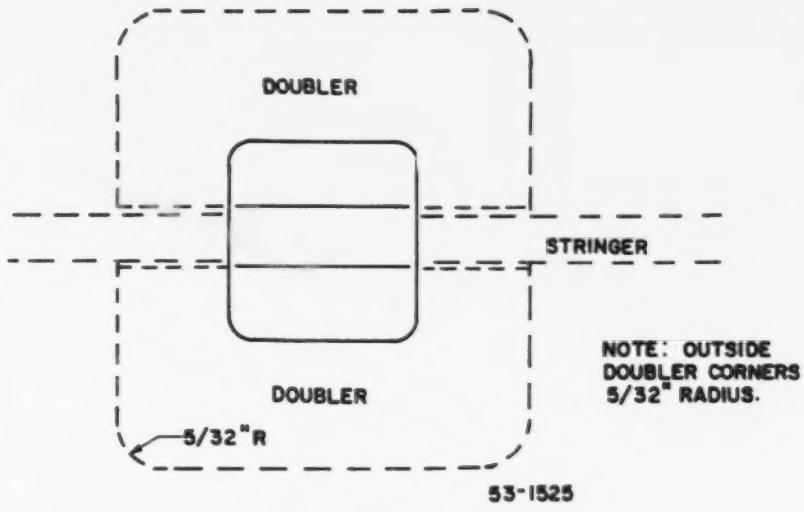

Figure 4-9. Doubler locations — stringer repair.

4. If the size of the stringer cutout is 3 inches, edge distance requirements are 1/4 of an inch, and existing rivet pitch is 1 inch, what would be the overall length of the stringer splice when fabricated?

5. What determines the thickness of the material used for the skin doubler?

435. Cite a selection factor and principal material features involved in the techniques used to locate trim lines when fabricating a replacement filler for an aircraft opening.

When it is necessary for you to fabricate a replacement filler for an open area on an aircraft, you need special techniques to aid you in fitting the replacement part. You can locate the outline of the open area on the replacement material by the methods discussed in the following paragraphs.

Locating Skin Trim Lines with a Skin Scribe. A skin scribe, such as that shown in the lower section of

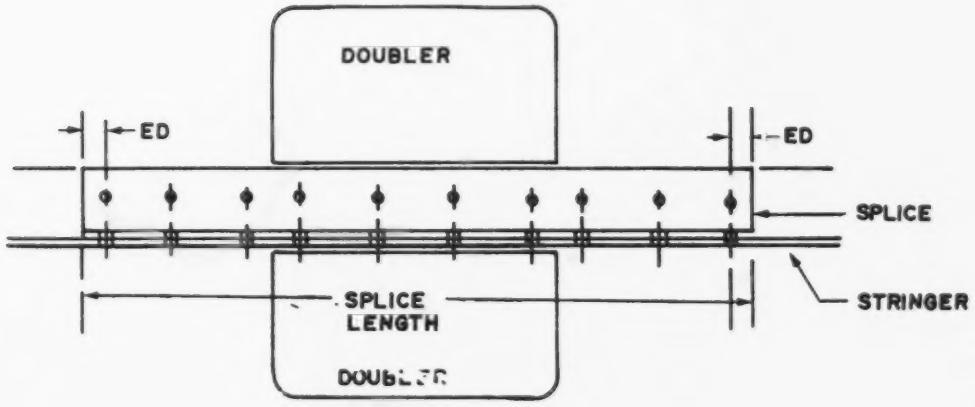

Figure 4-10. Determine the length of a stringer splice angle.

523

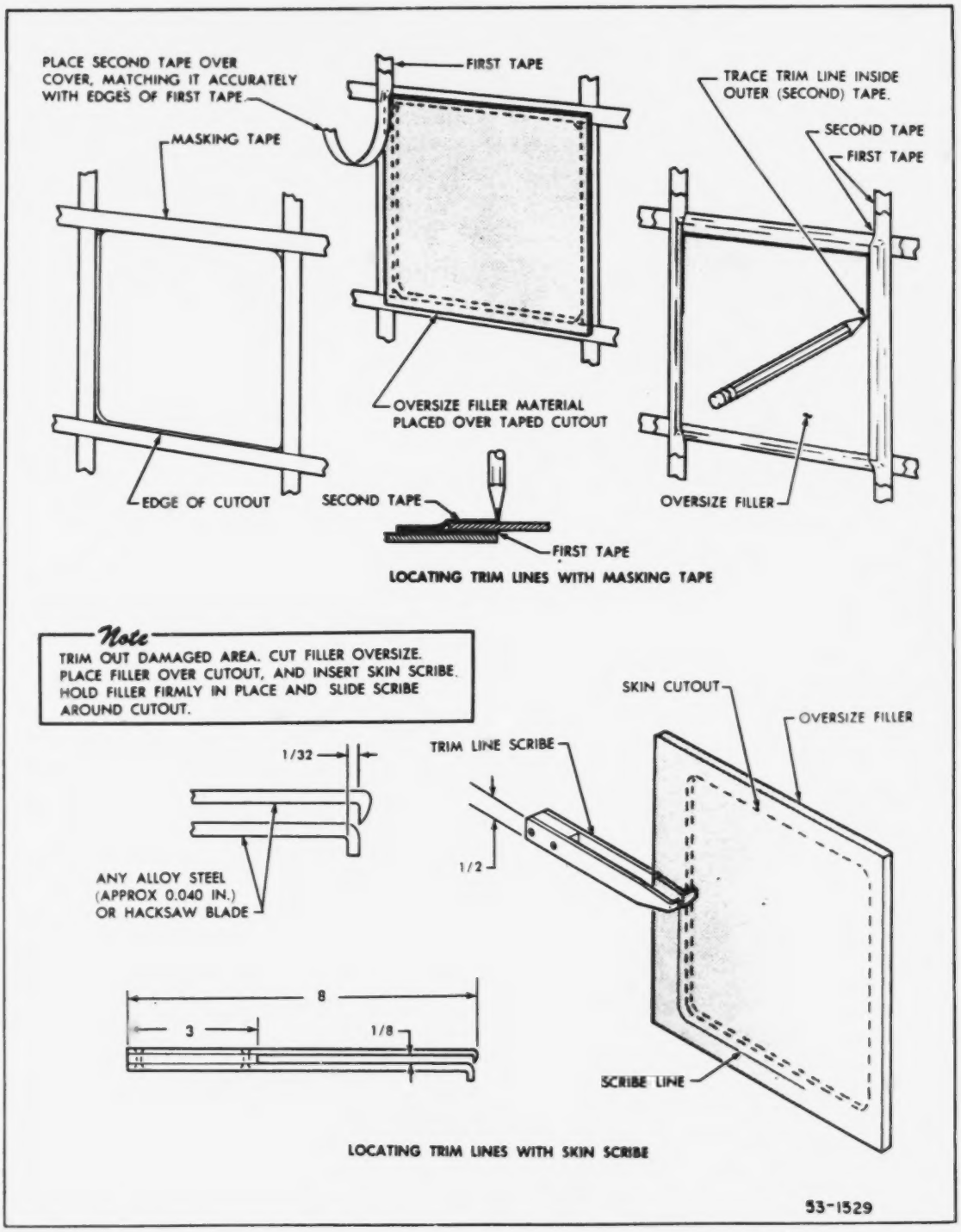
PLACE SECOND TAPE OVER COVER, MATCHING IT ACCURATELY WITH EDGES OF FIRST TAPE.
MASKING TAPE
FIRST TAPE
TRACE TRIM LINE INSIDE OUTER (SECOND) TAPE.
SECOND TAPE
FIRST TAPE
OVERSIZE FILLER MATERIAL PLACED OVER TAPED CUTOUT
EDGE OF CUTOUT
SECOND TAPE
FIRST TAPE
OVERSIZE FILLER
LOCATING TRIM LINES WITH MASKING TAPE
Note
TRIM OUT DAMAGED AREA. CUT FILLER OVERSIZE. PLACE FILLER OVER CUTOUT, AND INSERT SKIN SCRIBE. HOLD FILLER FIRMLY IN PLACE AND SLIDE SCRIBE AROUND CUTOUT.
1/32
ANY ALLOY STEEL (APPROX 0.040 IN.) OR HACKSAW BLADE
8
3
1/8
SKIN CUTOUT
OVERSIZE FILLER
TRIM LINE SCRIBE
1/2
SCRIBE LINE
LOCATING TRIM LINES WITH SKIN SCRIBE
53-1529

Figure 4-11. Methods of locating trim lines.

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figure 4-11, is made from any steel that is handy. Material that will take and hold a good scribing edge will last longer and give the most satisfactory results. This tool is equally useful to you in marking the "cut lines" of irregular, as well as straightlined, flush patches, coverplates, doors, etc. The turned-down tip on the lower strap is bent as sharply as possible; then the inside edge is rounded to about a 1/4-inch radius. The tip should be polished so that it will slide smoothly along the inside edge of the cutout being matched. Set the scribe point on the upper strap 1/32 inch outside the inner edge of the guide to allow for the desired skin gap. File the edges of the cutout to be matched or sand them smooth. Place the oversized filler sheet over the hole and hold it firmly in place while you draw the scriber around it, as shown in figure 4-11.

Locating Skin Trim Lines with Masking Tape. You can locate the trim lines for flush patch fillers, access covers, etc., when there is no access to the backside for marking, using masking tape, as shown in the upper section of figure 4-11. This method is the best to use when employed on rectangular openings. File the cutout to be matched or sand it smooth. Cut the filler sheet slightly oversize and form it to match the molding of the repair area. Align strips of masking tape along the edges of the opening to form a frame. Center the filler sheet over the opening and tape it down with tape of the same width as used underneath. Carefully align the outer edges of the outer and second tape with the first layer and pull it tightly over the filler. (Do not press tape into corners formed by edges or filler and base structure.) When thinner gages of filler material are used, closely match the inner edge of the outer tape to the edges of the cutout. When the filler material is thick, the outer tape will fall a little short of matching the edges of the cutout. Unless you compensate for this when marking, the filler will be too large for the opening.

Exercises (435):

1. What factor influences your selection when you select a material to fabricate a skin scribe for locating trim lines?

2. Why is the upper strap on a skin scribe longer than the lower strap?

3. To what shaped openings is the tape method of locating trim line best suited?

4. The amount of mis-match between the inner edges of the tapes when you are using the tape method of locating trim lines is directly proportional to what physical feature of the filler plate?

4-2. Installation of Repair Parts

The final step in the repair process is the installation of the repair parts. All previous steps have been leading up to this final step. The extra time you took in planning and fabricating the repair parts will payoff now during the installation of the repair parts. The quality of your workmanship will be reflected by the skills you demonstrate during the installation of repair parts. Therefore, it is important that the procedures discussed in the following paragraphs be closely observed.

436. Clarify selected procedures, problems, determinants, and material amounts related to installing previously fabricated repair parts.

The final operations in completing a repair consist of drilling and countersinking (if required) the fastener holes to the proper diameter and then riveting the repair parts into place.

Final Drilling Procedures. Prior to this time, all fastener holes have been pilotdrilled. When drilling the fastener holes to the correct diameter, celcoe the repair part in place on the part being repaired. This process reduces the possibilities of misaligned holes on the repair parts and the part being repaired. Also, when countersinking is required—as in the case of a flush patch—the doubler/s should be in place to provide a guide for the pilot on the countersink.

Where a repair part is to be installed over countersunk or dimpled holes, the fastener holes in the repair part must be dimpled. When the repair part cannot be dimpled, use tapered washers. Figure 4-12 illustrates the step-by-step procedures to use in fabricating tapered washers. After they have been fabricated, insert them into the countersunk holes of the part being repaired. This action fills in the space created in the fastener hole when the repair part and the part being repaired are fastened together.

In situations where the repair part must be dimpled and the part being repaired has non-countersunk or dimpled holes, you must accomplish sub- countersinking. "Sub-countersinking" consists of countersinking the fastener holes in the part being repaired so that the dimples will fit inside the countersunk areas of the fastener holes. Before accomplishing subcountersinking, be sure that the material being countersunk is thick enough so that the material will not be weakened by countersinking. After all holes

STEP 1 SELECT FASTENER WITH CORRECT HEAD SIZE TO FILL EXISTING COUNTERSINK.

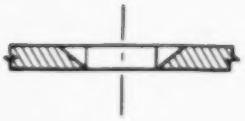
STEP 2 CLAMP SHANK OF RIVET FIRMLY IN DRILL VISE, SHANK POINTING DOWNWARD.

STEP 3 PILOT-DRILL HOLE DOWN THRU EXACT CENTER OF FASTENER UNTIL DRILL ENTERS SHANK OF FASTENER. USE DRILL PRESS IF AVAILABLE.

STEP 4 SELECT DRILL THE SAME SIZE AS SHANK OF FASTENER, AND DRILL DOWN THRU EXISTING PILOT HOLE. FASTENER HEAD SHOULD COME OFF AND REMAIN ON DRILL.

STEP 5 REMOVE HEAD FROM DRILL, AND CAREFULLY DEBURR RAGGED EDGE.

STEP 6 USE DRILLED-OFF FASTENER HEAD AS TAPERED WASHER TO FILL EXISTING COUNTERSINKS.



Note

1. WHEN DRILLING OUT EXISTING FASTENERS THAT ARE TO BE REMOVED, USE THE ABOVE PROCEDURE, AND SAVE REMOVED FASTENER HEADS FOR USE AS TAPERED WASHERS WHEN REPAIR IS BEING ACCOMPLISHED.
2. TO PROVIDE THE PROPER CLAMPING ACTION, THE OUTER SURFACE OF THE TAPERED WASHERS MUST BE FLUSH TO 0.010 INCH ABOVE THE SURFACE THEY ARE BEING INSTALLED IN. UNDER NO CIRCUMSTANCES SHOULD THE TAPERED WASHERS BE BELOW THE MOLDLINE OF THE SURFACE THEY ARE BEING INSTALLED IN.
3. ALUMINUM TAPERED WASHERS SHOULD BE USED IN ALL ALUMINUM SKINS; HOWEVER, IF SIZE IS A RESTRICTION, TAPERED WASHERS MADE FROM STEEL FASTENERS MAY BE USED. IT MAY ALSO BE NECESSARY TO MACHINE TAPERED WASHERS FROM ALUMINUM OR STEEL BAR STOCK WHEN THE CORRECT-SIZE FASTENERS ARE NOT AVAILABLE.

Figure 4-12. Fabrication procedures for tapered washers.

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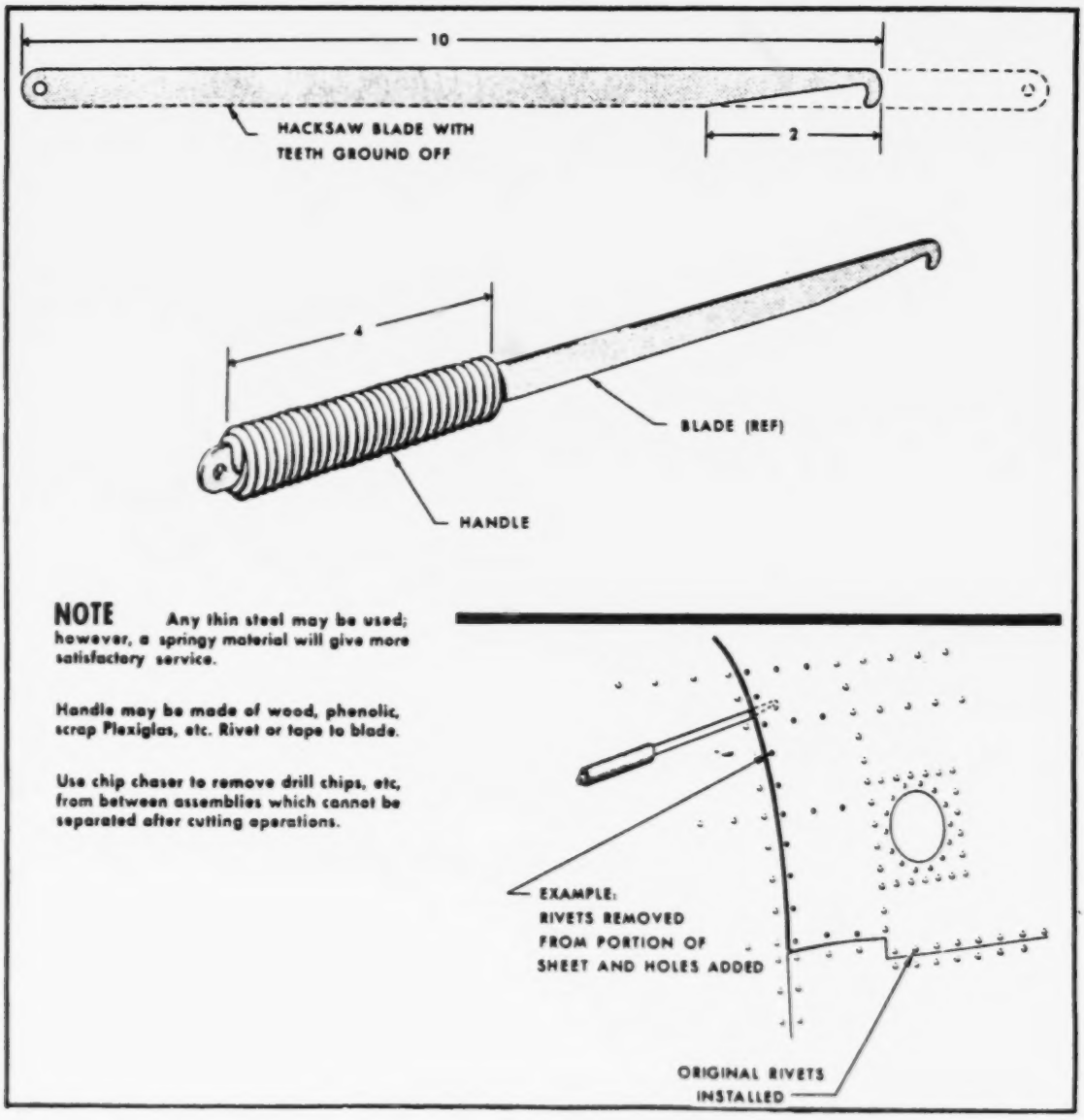

10
HACKSAW BLADE WITH
TEETH GROUND OFF
2
4
BLADE (REF)
HANDLE
NOTE Any thin steel may be used; however, a springy material will give more satisfactory service.
Handle may be made of wood, phenolic, scrap Plexiglas, etc. Rivet or tape to blade.
Use chip chaser to remove drill chips, etc, from between assemblies which cannot be separated after cutting operations.
EXAMPLE:
RIVETS REMOVED
FROM PORTION OF
SHEET AND HOLES ADDED
ORIGINAL RIVETS
INSTALLED
53-1482

Figure 4-13. Fabrication procedures for a chip chaser.

have been drilled, disassemble the repair parts for the removal of edge burrs and drill chips. File all edges or sand them smooth and deburr holes with appropriate tools. Also, remove drill chips from between adjacent parts and contacting skin surfaces. Figure 4-13 illustrates a tool that you can fabricate for chip removal purposes.

Application of Corrosion Preventatives. Prior to installing the repair parts, you need to apply a corrosion preventative to all faying surfaces. This also includes the part being repaired. The most common preventative you will use is an aerosol can of zinc-chromate primer. This primer is available in a variety of colors. But before you can apply the primer, the surfaces must be clean. To clean the surface, use a clean, soft rag and Methyl-Ethyl-Ketone (MEK). Remove all dirt, grease, and oil from the surface. Remember that there is oil in the pores of your skin, so once you have cleaned the surface, keep your hands off it. The MEK will leave a white film residue on the surface; so take another clean, soft rag and remove the film. At this point the area will be ready to be primed.

You must mix the can of zinc-chromate before application of it, as is true of all paint. Do this by

A—TOTAL RIVET LENGTH
B—GRIP LENGTH
C—AMOUNT OF RIVET LENGTH NEEDED FOR PROPER SHOP HEAD (1½ X RIVET DIA.)
D—INSTALLED RIVETS

53-1446

Figure 4-14. Determining the length of rivets.

shaking the can for approximately 1 minute. There is a metal agitator (ball) inside the can which does the mixing. When the primer is thoroughly mixed, hold the can about 10" to 14" from the surface to be sprayed. With the opening in the sprayhead pointed toward the surface to be sprayed, press down on the nozzle and start moving the can in a slow left-to-right motion to produce a THIN, even coat of primer. After the spraying operation has been completed, turn the can upside down and depress the nozzle to clean the sprayhead.

Riveting Procedures. The sequence of riveting the repair parts in position will vary from repair to repair. For flush repairs, usually you install the doubler first, then the filler. For repairs involving a number of different parts, you must follow some type of installation sequence. This approach eliminates your having to remove previously installed repair parts. Of course you may encounter such problems as not being able to buck certain rivets or deforming the shop heads of previously installed rivets.

Once you have developed your plan of installation, your next step is to determine the lengths of the rivets required. Figure 4-14 illustrates the method to use when determining the length of rivets required. When determining the total length of a rivet for installation, you need to know the combined thickness of the materials to be joined. This measurement is known as grip length, and it is illustrated in B of figure 4-14. the total length of the rivet (see A of fig 4-14) should be equal to the grip length plus the amount of rivet shank necessary to form a proper shop head. The length of the rivet required to form a shop head is 1½ times the diameter of a rivet shank, as illustrated in C of figure 4-14. Properly installed rivets are shown as D in figure 4-14. Note carefully the method used to measure total rivet length for countersunk rivets and the other type of head.

The material thickness of the area must also be taken into consideration. Thus, for thin material, excessive riveting pressure will cause the repair area to sink inward. Therefore, proper adjustment of the rivet gun for the diameter rivets being installed and the correct weight bucking bar are very important when riveting in thin materials is involved.

Do not overlook the sequence of rivet installation For example, when installing rivets in any repairs, spot the first few rivets throughout the rivet layout. Why? Because this will keep the repair parts from shifting during the riveting process. Starting at one side of a repair and working toward the other side will cause the rivet holes to be misaligned as you progress toward the other side. This is especially true when the repairing of a curved surface is involved.

In work situations involving the replacement of a skin panel, you should start riveting in the center, working toward the side. Once the center area has been riveted, alternate the remaining rivets from side to side and top to bottom, working outward. It is recommended that you skip a few rivets in a row, install a rivet, then come back to the ones you have passed over. This process keeps the metal from shifting, helps maintain the proper contour, and reduces the possibility of misaligned holes at ends of the panel.

Exercises (436):

1. When should the fastener holes in repair parts be drilled to the correct diameter?

2. When are tapered washers required when installing repair parts?

3. When is sub-countersinking necessary when installing repair parts?

4. What type of corrosion preventative will you most often use?

5. What problems can be created by *not* having a planned sequence of installing repair parts?

6. What must be known to determine the correct length of rivets to use in a repair?

7. How much additional rivet material is needed to form a correct shop head?

8. Why is it recommended that the first few rivets in a repair be spotted throughout a fastener layout rather than working from one side to the other?

437. Supply reasons for applying aerodynamic smoothing compound to a completed repair and for mixing it properly; name such compound types, and state the factor determining how excess compound is removed after curing.

After the repair parts have been installed, it may be necessary to apply aerodynamic smoother to the seams, gaps, and the manufactured head of the fasteners. This is required primarily to restore the aerodynamic smoothness requirements to the repair area. Also, the possibility of corrosion is reduced by eliminating areas where dirt, moisture, etc., could collect.

A specific type of smoothing compound or filler is available for each aircraft that is critical in aerodynamic smoothness requirements. Such compounds are manufactured in the form of pastes and putties. Basically, two types exist: (1) the one-part compounds, those of the evaporative type whose chemical action controls the speed of curing; and (2) the two-part compounds, those composed, of a filler and accelerator which controls the setup or curing time. Before selecting any smoothing compound or filler however, consult the applicable technical order for requirements.

Preparation of Area. In preparing the area, first, remove all primers or organic paint finishes to a distance along each side of the area (recommended by the applicable technical order) to which the filler or smoothing compound is to be applied. Second, clean and wipe the area to be filled, using aliphatic naphtha, MEK, or a specified cleaner. Apply these cleaners with a clean cheesecloth or a brush. After applying the cleaner, rinse the area clean with water and wipe or allow its surface to dry thoroughly. You should repeat the whole cleaning process until the surface is completely free of residual film or any foreign matter.

Mixing Procedures. The compounds you'll use must be measured and mixed by weight or volume in proportions recommended by the manufacturing. Here, closely follow the directions for mixing (found on the label of all containers).

Always mix these compounds at room temperatures, and be sure that they are used within a specified time. A thorough mixing of smoothing compounds or fillers is necessary, since poorly mixed compounds will lack the proper consistency, causing failure to cure properly, improper setup or hardness, and/or air bubbles, which cause pits or holes in the finished surface. Toxic fumes are given off during the blending process. To minimize these fumes, ventilate the area and never inhale the vapors.

Application of Compounds. After properly cleaning the surface and thoroughly drying it, apply the smoothing compound or filler with a putty knife or spatula. Work the compound over the area evenly and force it into slots, crevices, or heads of recessed fasteners, allowing a slight (overfill) excess for shrinkage during curing time.

Curing and Finishing. The smoothing compound or filler must be allowed to dry (cure) thoroughly according to a specific time given for prevailing conditions. Consult the applicable technical order for the proper curing time at normal room temperatures and for other time intervals acceptable for the specific compound being cured. After the area has been completely cured (dried), then remove the excess compound either by filing and/or sanding, depending upon the hardness of the compound surface. While removing the excess compound, take care to avoid marring the surfaces, preventing unnecessary repairs to the areas. Clean the area with recommended cleaners and allow it to dry thoroughly. Prime the area with a suitable primer.

Exercises (437):

1. What is a secondary reason for applying aerodynamic smoothing compound to a completed repair?

2. Why is it important that the smoothing compound be mixed properly?

3. What are the two types of aerodynamic smoothing compounds?

4. What determines the method used to remove excessive aerodynamic smoothing compound after curing?

438. Specify the factors to consider and items to check in inspecting completed repairs for strength, corrosion security, and TO compliance; give the reason for a fabricated repair's failure, despite its requirement compliance.

After the completion of any repair, you must perform a final inspection. Final inspections are made to determine whether or not repairs have been accomplished in accordance with requirements and specifications listed in the appropriate technical

manual of structural repair. The inspections you perform are not to be confused with those made by an authorized inspector; yours are simply checkpoints to assure that repairs have been made properly before the aircraft is declared to be in serviceable condition. These final checks often turn up discrepancies which have been overlooked and thus might cause additional damages. Whether these inspections are embarrassing or pleasant to you is mostly up to you. If you are alert and apply yourself, there will be few, if any, defects in your work; you can then be justly proud of a job well done. Your supervisor will appreciate it, too, for you will have increased his faith in your ability and, also, will have provided him with more time to devote to his other duties.

You must keep many factors in mind when you are inspecting fabricated and repaired items. Among the more important such factors are (1) the tools of inspection, (2) the strength factor, (3) the weight factor, (4) the contour factor, (5) corrosion detection, and (6) comparison of the inspected items with drawings and specifications.

Tools of Inspection. The tools of inspection you have to use are few, since the inspector checks by sight, feel, and measurements. To do this, however, he must have the knowledge and experience gained through much study and practice. Briefly the standard tools for inspection are these:

- Flashlight—Used to illuminate dark areas.
- Mirror—Used to look into areas where you ordinarily could not see. Sometimes a handle is attached so that the mirror can be used in much the same way a dentist uses his mirror to look at your teeth.
- Six-inch scale—Used for measuring such things as rivet pitch, edge distance, and shop heads.
- Micrometer—Used for making precision measurements, such as thickness of skin or members.
- Feeler gage—Used for checking loose rivets.
- Grease pencils—Used for marking defects discovered during inspection.
- Pencil and pad—Used for making notations of the findings.

Strength Factor. Strength is the most important factor for you to consider when you are inspecting repairs made to damaged aircraft. After all, the original strength must be returned to structural members if the aircraft involved is to be considered in good repair. Points to consider in maintaining strength are (1) correct gage and composition of materials; (2) proper size, type, and installation of fasteners; (3) heat treatment, and (4) cutout radius and edge distance.

Correct gage and composition of materials. It is vital that you use the correct gage and composition of materials in making repairs, since these two factors are of the greatest importance in the process of restoring strength to an aircraft. Consequently, the airframe repairman cannot afford to guess when selecting materials for repairs. Even though he will ordinarily know whether the damage is in a highly stressed area or not, he will not know the actual material strength measurement. The use of a repair piece which has less strength than the original could cause failure of the part.

To avoid such failure when making aircraft repairs, the airframe repairment should use the same gage and composition of materials as those which were used originally by the manufacturer. Note that the use of the same gage is not enough in itself—the composition and temper designation must also be the same.

It is sometime permissible for you to substitute a metal of greater strength for one of less strength if there is no appreciable difference in weight and provided no *corrosion hazards* are involved (such hazards as occur when dissimilar metals corrode or when unclad materials are substituted for clad materials). When making final inspections, always consult an approved metals interchangeability chart if substitutions have been made.

Size, type, and installation of fasteners. Insert or patch repairs must not be greater than the limits established in the technical manual of structural repair for a specific aircraft. Classification of damages must be correct in order to maintain the strength of the aircraft through repairs suggested by the classification. Rivets and bolts must be of the type, size, and condition specified by repair drawings or must be a specified allowable substitute.

The height of the shop head of a rivet should be one-half of the shank diameter, and the diameter of the shop head should be one and one-half times the diameter of the shank. If there is any appreciable deviation from the rule, remove the rivet and replace it. The condition of the shop head is also important if the strength is to be maintained. The head should be uniform in size and evenly bucked with a smooth bucking bar. If shop heads feel rough or sharp on the edges, they were probably driven too slowly and became work-hardened before the riveting was complete. Because these rivets do not have maximum strength, you should remove and replace them. If the manufactured head has been damaged by the river set, the strength cannot be considered adequate in stressed areas.

Rivets must be of the same composition as those used by the manufacturer. True, a larger diameter is sometimes permissible, provided too many of them are not used. But a smaller diameter rivet must *never* be used as a replacement or a substitute. Head styles are also important, since different head styles provide varying degrees of strength.

When inspecting the installation of bolts, here are some of the things for you to look for: (1) correct diameter to assure a tight fit, (2) correct composition of the bolts, (3) correct grip length, and (4) correct installation. In connections with (4), for example, threads should not bear into the material which is bolted.

Heat treatment. Be sure that aluminum alloys used for stressed area repairs are the type which can be heat-treated. It is often necessary to use annealed aluminum alloys or to anneal heat-treated alloys in order to form complicated parts. Part of the job of inspecting finished repairs will be to see that these parts have been returned to the correct heat-treated condition after they have been formed and before they have been installed on the aircraft.

Cutout radius and fastener layout. When aluminum alloys are formed or when damage cutouts are made, it is necessary to have a radius on inside corners in order to prevent the creation of a highly stressed area at the point of the bend or at the corner of the cutout.

The strength factor can be influenced quite easily by improper allowance between the rivet and the edge of the material. Corner radii are, in most cases, the same as the edge distance from the center of the rivet to the edge of the material. Recommended edge distance is 2½ times the diameter of the rivet; minimum and maximum edge distances are established at 2 and 4 diameters, respectively.

It is interesting to note that all rules for rivets, edge distance, corner radius, bend radius, relief hole diameters, and pitch are determined either directly or indirectly by the thickness of the material being used. For example: (1) the diameter of a rivet is usually 3 times the thickness of the sheet to be riveted; (2) edge distance, 2½ times the rivet diameter; (3) corner radius, usually the same as edge distance: (4) rivet pitch, 6 to 8 rivet diameters; (5) transverse pitch, 3/4 pitch distance; (6) minimum bend radius, 3 times the thickness of the material for hardened aluminum alloys; and (7) minimum relief hole diameter, the same as minimum bend radius. The one exception to these rules is this: in rivet pitch and transverse pitch, use the manufacturer's pattern when possible.

During inspection, other factors which you must consider are weight, contour, and corrosion. We will discuss them in this order next.

Weight Factor. The delicate balance of the modern aircraft approaches that of a timepiece. Thus, the addition or subtraction of weight as a result of repairs can have a very definite effect on flight characteristics. For this reason, the airframe repairman must not permit his repairs to exceed additional weight limits allowed for specific repairs. Consequently, you should be weight conscious at all times when you are making repair inspections.

Contour Factor. When making repairs, you must keep the shape of the different parts as close as possible to that of the original. To do this, check parts against the damaged parts to be replaced or against duplicate structures in the aircraft. Contour is especially important on the outer surfaces on the aircraft and on inner surfaces—such as those of bulkhead, ribs, and formers—all of which transfer their shape to the outside skins.

As an illustration of the importance of the contour surface on the high-speed aircraft of today, a few scratches and scuff marks on the wings, such as those caused by someone's walking on them, can derease the airspeed. Furthermore, a flat place or hump could have even a greater effect on the speed and performance of the aircraft. Consequently, you should always check the contours closely when you are making final inspections.

Corrosion Factor. Any type of corrosion, especially that occurring between dissimilar metals—which has been discussed at length in Volume 2 of this CDC, is accelerated by the presence of moisture. Therefore, here are some good places to look for evidence of corrosion— (1) around rivets, (2) around joints in the metal, (3) in crevices where dirt and cleaning compound may collect, (4) in highly stressed areas, and (5) where unlike metals come into contact or are separated by a water-absorbent material, such as wood, fabric, or sponge rubber.

Any time two pieces of aluminum alloy are fastened together, even though they are of the same composition, they should have coatings of zinc chromate primer on the contacting faying (joining) surfaces. Take care to remove all metal chips, such as those which might be caused by drilling operations, to allow for close fit of the materials and to prevent scratching.

Scratches which penetrate the cladding on aluminum alloys should not be allowed while repairs are being made, unless appropriate measures have been taken to prevent corrosion, and only then if the depth is not sufficient to weaken the metal. By close inspection, you can usually detect the presence of corrosion and take the necessary preventive measures. However, if you are in doubt as to whether or not the effects of corrosion have weakened a part, reject it.

Now that we have discussed the general rules for inspection of a fabricated or repaired part or structure, let us consider the inspection of these same areas to insure compliance with drawings and specifications.

Comparison of the Inspected Items with Drawings and Specifications. Any time a drawing or specifications is received, the information contained has been incorporated into the drawing for a specific purpose. Normally, it is not our option to change specifications. If they are not correct, the authority to change lies with the originator of the specification, drawing, or blueprint.

In Volume 2 of this course, we have discussed drawings and specifications. In our discussion there, we explained the need for proper interpretation of symbols and the need for accuracy when transcribing the information contained in the prints and specifications. You must therefore ask yourself the following questions during your inspection of a part or repair fabricated, using information from a print or specification prior to approval of the completed job:

- Scale—has proper interpretation been made of the scale signified?
- Material composition—has the material specified been used?

- Heat-treatment—has the material been properly heat treated to the temper designation specified?
- Tolerance—are the dimensions of the completed part within the tolerances specified?

If the answer to any of these questions is "No," and if the lack of compliance with the specifications may change the value of the item, it does *not* pass inspection. Finally, although it is not usually stated in specifications, poor quality of workmanship should be another of the basic reasons for turning down a fabricated product.

Exercises (438):

1. What are the main factors to consider when inspecting a completed repair?

2. What specific items are checked to insure that the strength factor was maintained, when inspecting a repair?

3. If you are doubtful whether the effects of corrosion have weakened an aluminum part, what should you do?

4. When comparing a completed repair to TO specifications, what questions should you ask yourself?

5. If a fabricated repair meets the required specifications, but yet fails the inspection, what most likely was the reason for it failing?

Special Repair Situations

AS YOU MUST HAVE realized from the previous chapters, repair requirements will vary from repair to repair. You will have to modify your repair procedures to meet the needs of each repair situation. This chapter will introduce special repair situations that will call for added experience and skill on your part. Spotweld repairs, metal fuel tank repairs, and structural sealant requirements are types of special repair situations.

5-1. Spotweld Repairs

Many of the metals used in the construction of today's aircraft are adaptable to electrical resistance or spotwelding. This method of fastening metals produces a flush effect on both surfaces with comparatively high shear strength.

439. Give the characteristic features of spotwelds, cite the inspection criteria associated with spotweld, and define "nugget."

General Information. Spotwelding is a type of resistance welding in which sheets of metal are fused at a series of separate spots. An electric current is passed through the sheets at the spot or point of electrode contact. This is accomplished by placing two or more pieces of metal between a pair of alloy copper electrodes. An electrical impulse of low voltage (electromotive force) and high amperage (strength of the electric current) is discharged between the poles formed by the electrodes. As a result, the metal becomes molten and fuses together at the point of contact of the two or more sheets. This point of contact or spot fused is called a "nugget." The nugget reacts against shear loads in the same manner as a rivet does. The diameter and thickness or penetration of the nugget depends largely upon the type and thickness of the metal to be spotwelded.

Electric resistance welding is easier, cleaner, quieter, and quicker than arc standard fastening procedures. For instance, the heat can be localized at the exact spot where the weld (or fusion) is desired. Also, the amount of heat and extent of fusion can be controlled. Furthermore, addition of a filler metal to the welded area is not required. The combining of two pieces of metal without loss of strength is the prime object of spotwelding.

Inspection of Spotwelds. The outer surfaces of a spotweld should be smooth, free of cracks and pits. Therefore watch for spotwelds showing evidences of being cracked or pull through the surrounding surfaces; these are types of spotweld failures. Of course, spotweld failure may also occur between the sheets of metal without any outward signs of failure within the spotwelded area. In such cases, you can usually detect such hidden failure by checking the mating of the surfaces along the edges of the sheets. Any separation or lifting up of the outer surface is a definite sign that the spotweld has failed. In cases where it is impossible to check the mating surfaces at the edge, you can use a tapping test. A good spotweld will give off a solid metallic ring when tapped. In contrast, a sheared (separated) spotweld, when tapped, will produce a dull sounding response, indicating a lack of surface contact. The types of failure found during your inspection will influence the type of repair required.

Exercises (439):

1. How are spotwelds formed?

2. What is meant by the term "nugget"?

3. What factors determine the thickness or penetration of the negget?

4. How should the outer surface of a good spotweld lock?

5. How does resistance welding compare to standard fastening procedures?

6. Cite two methods to use when inspecting for sheet separation that are spotwelded together.

440. Point out the repair type, material selection factors and procedures related to repairing spotwelds and state the importance of knowing sheet thickness and the time to make flush skin repairs when spotwelding.

Repairs accomplished to spotwelded areas are classified as either major or minor repairs. The type of spotweld failure, the number of spotweld failures within a certain area, and the location of the spotwelds will directly affect the type of repair you must install.

Minor Repairs. In cases where a spotweld shows evidence of small cracks within the nugget area, you may make a minor repair. This consists of installing a rivet through the center of the nugget, with a rivet large enough to remove the crack. The hole is then countersunk and a flush type rivet is installed. The material composition of the rivet must be the same as the spotwelded material in order to eliminate corrosion. Also, you must consider the thickness of the spotwelded area when selecting the diameter twist drill you need. If the diameter of twist drill required to remove the cracked area is such that the countersinking limitations of the welded materials will be exceeded, you must perform a major repair.

Major Repair. Whenever a spotweld fails completely and the skin separates from the structural member, you must make a major repair, as shown in figure 5-1. To this end you must remove the top skin and the nugget, using a counterbore.

Be sure to employ a counterbore of the correct size and diameter. Figure 5-2 points out the selection criteria based on the diameter of the nugget and sheet gage of the welded area. Counterboring is accomplished in a manner similar to that of countersinking. Exercise care not to go deeper than the top skin for a major spotweld repair.

Once the nugget and skin have been removed, you must manufacture a spacer the same diameter as the counterbore and the thickness of the original top skin. Insert the spacer into the counterbored hole. In addition, you must prepare a washer. This washer must be at least one gage heavier than the skin and six times larger than the rivet diameter, with chamferred edges. If there are more than two spotweld failures at the same spot, you should repair the area, using flush patch procedures.

Sometimes during a repair situation it may be necessary for you to deliberately shear (separate) spotwelds. When this is necessary, you must use a spotweld shearing chisel, as shown in figure 5-3, and special procedures. Figure 5-4 explains in detail all of the operations required in shearing spotwelds.

Exercises (440):

1. What type of repair procedures must you use to accomplish a minor spotweld repair?

2. What two factors must you consider when selecting the repair material for a minor spotweld repair?

3. Why is it important for you to know the thickness of the sheet spotwelded prior to performing a minor spotweld repair?

4. How are the nugget and top skin removed when you are making a major spotweld repair?

5. In what way should the reinforcement washer compare to the size of the fastener used and the thickness of the top skin when you are making a major spotweld repair?

6. When is it necessary for you to make a flush skin repair in spotwelded structures?

5-2. Repair of Aircraft Metal Fuel Tanks

The repairing of the metal fuel tanks of an aircraft presents you, the airframe repair specialist, with a unique challenge. Not only must you restore the original strength and contour to the damaged fuel tank,

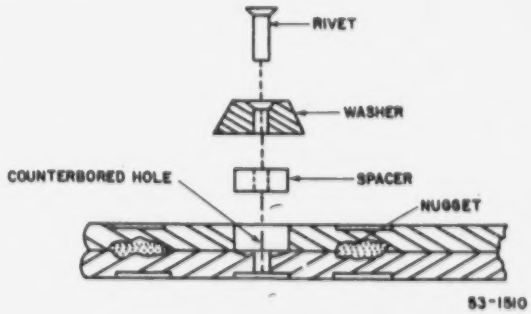
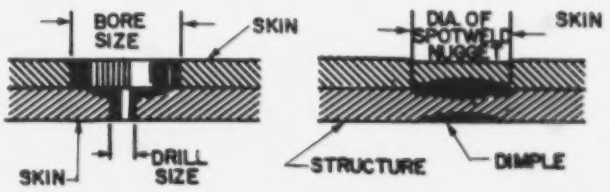


Figure 5-1. Major spotweld repair.



SPOT WELD TABLE

SHEET GAGE	DIAMETER OF NUGGET	BORE SIZE
016	1/8	1/4
020	9/64	1/4
025	5/32	1/4
032	3/16	1/4
040	7/32	1/4
045	15/64	1/4
051	1/4	1/4
064	9/32	3/8
072	19/64	3/8
081	5/16	3/8
091	11/32	3/8
109	3/8	3/8
125	3/8	3/8

RIVET	DRILL NO.
3/32	41
1/8	30
5/32	22
3/16	12

53-1515

Figure 5-2. Drill sizes for removal for spotwelds.

but you must also make the repair leak proof at the same time. During all phases of the repair, this thought must be foremost in your mind. Equally important are the safety precautions you must observe when repairing metal fuel tanks.

441. Define "integral fuel tank"; identify the normal location of such tanks, the material typically used for external tanks, and the sections of such tanks; and clarify why structural members of such tanks are usually welded.

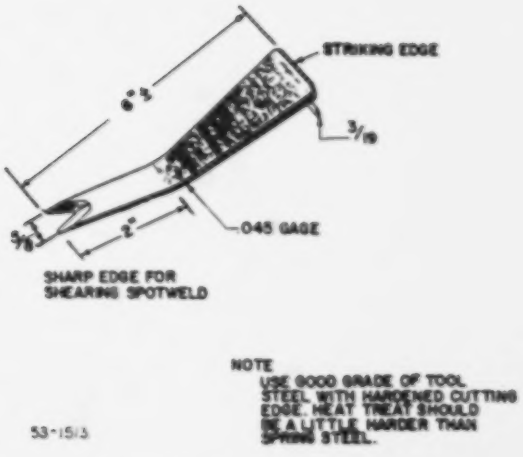


Figure 5-3. Spotweld shearing chisel.

Two separate types of aircraft metal fuel tanks—the internal and the external—exist. Some aircraft will have both types, while others will only have internal tanks. The construction features of each type are similar in some areas but differ in many ways, as you will see in the following paragraphs.

Internal (Integral) Fuel Tanks. Look at figure 5-5 and realize that an integral fuel tank is simply a part of the aircraft structure that has been built in such a manner that—after the seams, structural fasteners, and access doors have been properly sealed—it will hold fuel without leakage. Such fuel tanks are located in the vertical fin, fuselage, and/or wings, with the most common location being in the wing. Normally located between two main wing spars, the wing fuel tank will be capped off on the ends by sealed end ribs. The upper and lower skin of these fuel tanks can be standard aluminum sheets or milled skin. All aircraft that have the integral tank in the wing are often referred to as "wet wing" aircraft.

The construction of the integral tank will vary from aircraft to aircraft. The wing tank will generally extend from the front spar of the wing to the main wing spar and from the centerline of the aircraft to the wingfold rib. In aircraft with no wing-fold, it could extend to near the wing tip. The mating surfaces of the tank are built to extremely close tolerances to allow for maximum spacing. The skin, in most cases, is milled to obtain these close tolerances. In addition, special sealing methods must be used, with groove sealing being one such method, as shown in figure 5-6.

Grooves are used between milled or regular skin and spars, ribs and/or other castings. The groove is normally cut into the casting and filled by injecting a nonhardening sealant into the groove after the assembly is complete. Some aircraft use a dam in conjunction with the groove. The dam consists of a different type of sealant than the one in the groove and is normally in two thin layers on each side of the groove. Dams are installed at the time of manufacture and if repair is necessary, follow the procedures outlined for fillet sealant. Fasteners which hold the skin in place may be installed through the sealant groove to obtain maximum sealing.

External Fuel Tanks. Figure 5-7 illustrates the typical construction features of an external fuel tank. The basic structure of the tank consists of a weldable aluminum shell, with formed stiffening rings and former. Welding is used in place of a conventional fastening method (riveting or bolting) whenever possible. This procedure reduces the number of areas (seams and fastener holes) where leaks are most likely to occur. The skin panels are welded into skin assemblies, inside of which the internal members are welded. Three skin assemblies consisting of a front section, center section, and back section usually make up an external fuel tank. The front section is tapered to a rounded point for aerodynamic smoothness requirements. The center section is where the tank is attached to the aircraft. The rear section is tapered to a point with stabilizing fins attached. The sections are usually bolted together to permit access to internal components.

Exercises (441):

1. Define the term "integral" fuel tank.

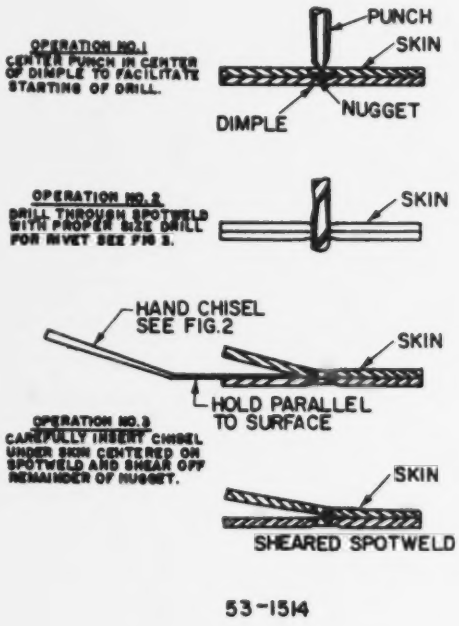


Figure 5-4. Method of shearing spotwelds for riveting.

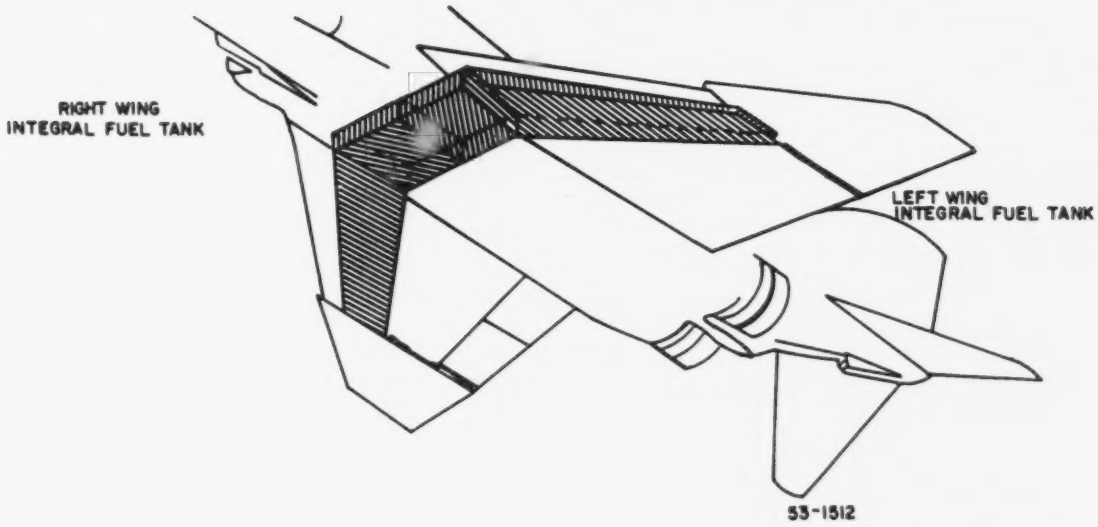


Figure 5-5. Internal (intergral) fuel tank.

2. Where are integral fuel tanks most often found?

3. What type of material is usually used for the skin assemblies of external fuel tanks?

4. Why are structural members of external fuel tank normally welded?

5. What are the individual sections of an external fuel tank?

442. Point out significant safety precautions to observe when repairing metal fuel tanks.

Whenever you are repairing metal fuel tanks, whether internal or external, you must follow special safety precautions for your safety and the safety of others. All of the safety precautions and instructions covered in this section are the *minimum* requirements, and they pertain only to normal work situations. Since it would be impractical for us to discuss all work situations involving repairs near or inside fuel tanks, we will not do this here. Therefore, you must work very closely with the fuel system specialist. Follow his instructions; he is the expert when it comes to safety precautions related to fuel tank repairs.

Fuel Precautions. You must take every precaution to avoid contact with fuels, inhalation of fuel vapors and accidentally swallowing of fuels. When or if any aircraft fuel comes into contact with human skin, a solvent action occurs. This removes natural fats and oil from the skin, leading to dermatitis. Also, any extensive vapor inhalations may cause serious illness, and the accidental swallowing of fuel can cause grave internal injuries and possible death. Furthermore, if any splashes or spills occur, involving eye contamination, they will produce immediate irritation and possibly the loss of sight. Obviously, then, if you are exposed to any of these conditions, seek medical attention immediately.

Working Precautions. Most such precautions involve common sense. For example, prior to entering a full systems repair area, you must remove shoes having exposed metal tacks. Similarly, if you are wearing flight deck shoes (which are allowed in the fuel system repair area), periodically inspect the bottom surfaces and remove any spark-producing material that may be lodged between the grooves and notches.

Special precautions apply whenever you enter an internal fuel tank. Here, for instance, you must remove all noncotton clothing and wear white static free coveralls, as shown in figure 5-8. The reason for this is to avoid the buildup of static electrical charges. Of course, you may wear cotton sweat shirts and pants in place of cotton coveralls. In internal fuel tanks, you must also remove your street shoes and personnel socks and put on white cotton socks, *just before* entering the tank. Now, take a few minutes to study closely the various illustrations making up figure 5-8. Note that a minimum of two men must be involved in any repair accomplished inside a fuel tank. In such cases, one man must be positioned

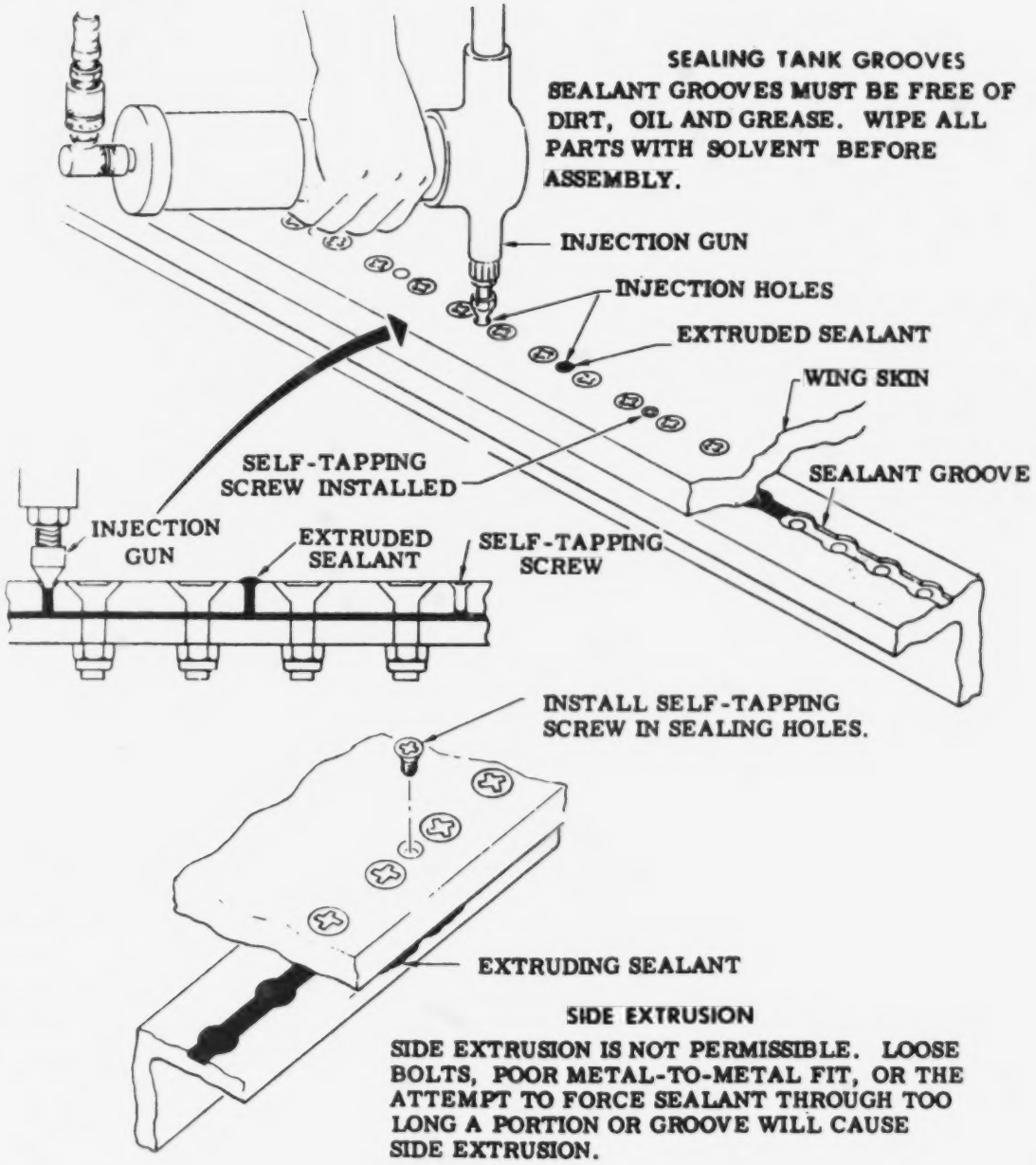

SEALING TANK GROOVES
SEALANT GROOVES MUST BE FREE OF DIRT, OIL AND GREASE. WIPE ALL PARTS WITH SOLVENT BEFORE ASSEMBLY.
INJECTION GUN
INJECTION HOLES
EXTRUDED SEALANT
WING SKIN
SELF-TAPPING SCREW INSTALLED
SEALANT GROOVE
INJECTION GUN
EXTRUDED SEALANT
SELF-TAPPING SCREW
INSTALL SELF-TAPPING SCREW IN SEALING HOLES.
EXTRUDING SEALANT
SIDE EXTRUSION
SIDE EXTRUSION IS NOT PERMISSIBLE. LOOSE BOLTS, POOR METAL-TO-METAL FIT, OR THE ATTEMPT TO FORCE SEALANT THROUGH TOO LONG A PORTION OR GROOVE WILL CAUSE SIDE EXTRUSION.

Figure 5-6. Groove sealing.

outside the tank near the tank opening, observing the man inside the tank and insuring that continuous ventilation (forced air) is provided into the tank.

Be sure that any power tools you use in fuel tank repairs are air-driven and inspect them carefully before using them to insure their safe condition. Also, of course, keep all toolboxes outside the fuel tank repair area. If you require tools in the area, hand-carry them in a cardboard box or canvas bag. Remember, too, to be sure that all lights used in fuel tank repairs are of an approved explosion-proof type. If extension cords are required, have them long enough to make all electrical connections outside the fuel system maintenance area.

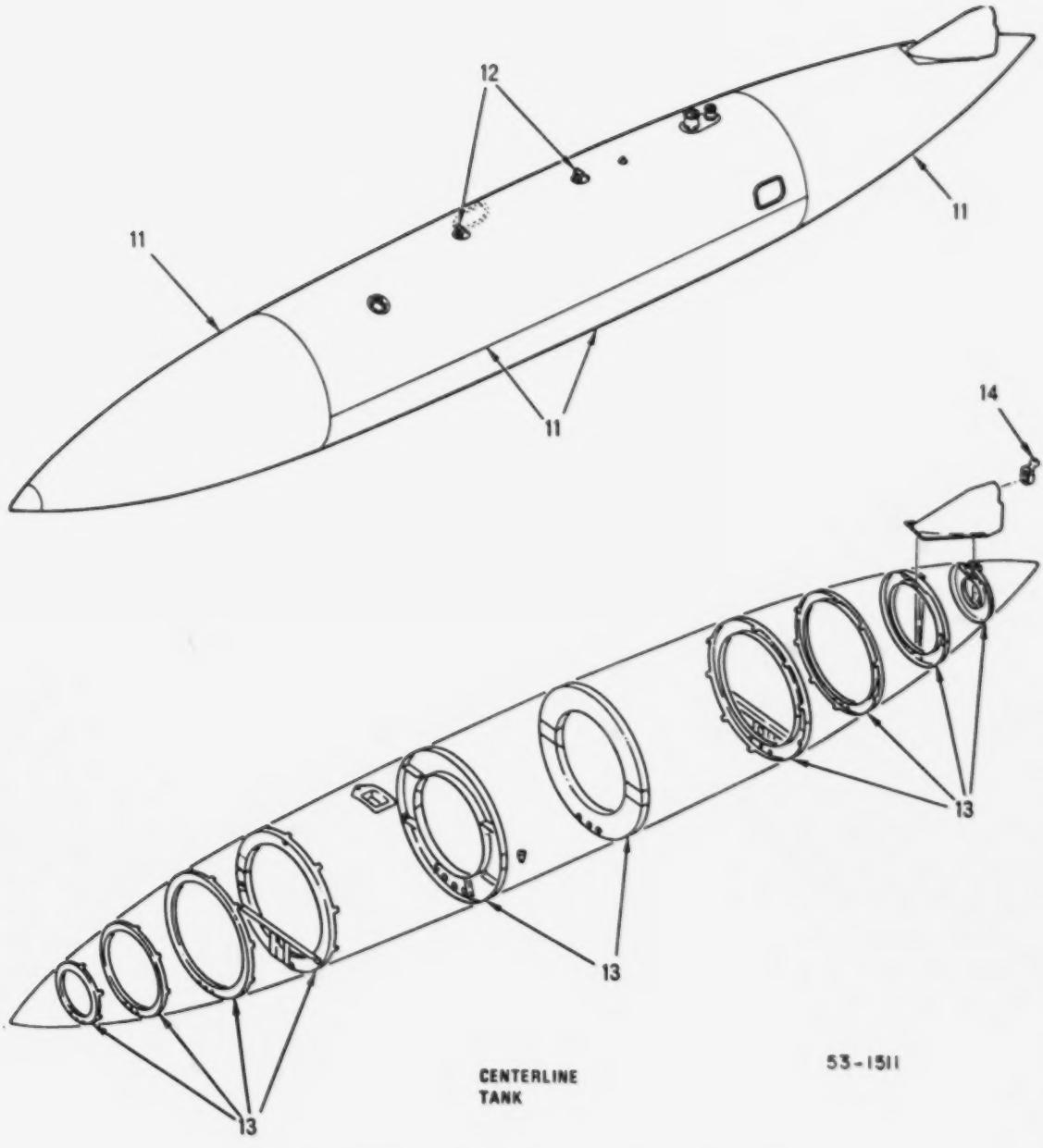


Figure 5-7. External fuel tank construction features (typical).

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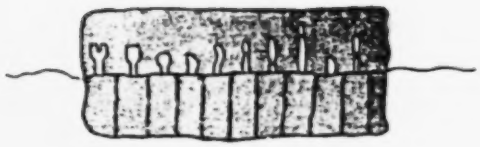
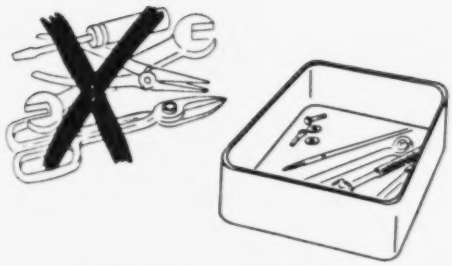
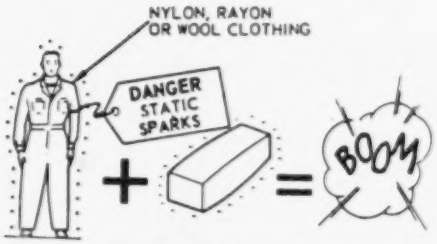




TOOLS OR PARTS CARRIED INTO THE TANKS SHALL BE CONTAINED IN CANVAS BAGS OR IN BOXES HAVING NO SHARP CORNERS OR EDGES

WEAR ONLY COTTON OUTER CLOTHING



FUEL CELL OR CAVITY
CONTAINING FUEL VAPOR

WARNING

"NO WOOLEN, SILK, OR NYLON OUTER, OR INNER CLOTHING SHALL BE WORN. A COTTON COVERALL, FITTING SNUGLY AT WRISTS AND ANKLES, WITH NON-SPARKING ZIPPER OR BUTTONS SHALL BE WORN."

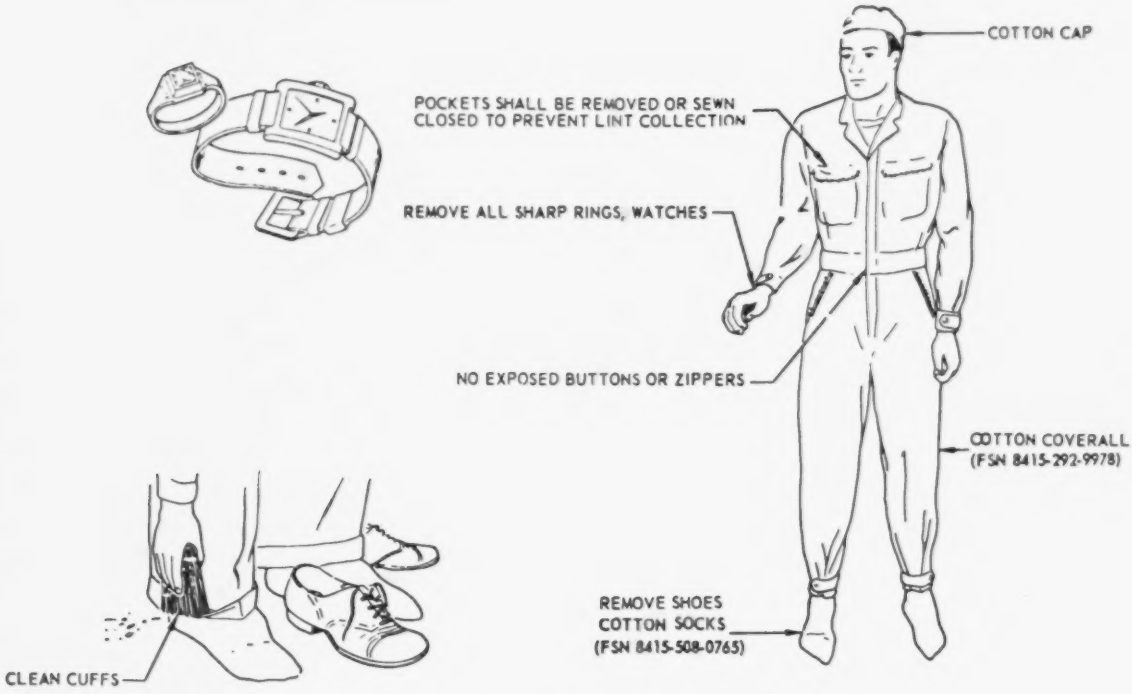


Figure 5-8. Personnel inspection prior to internal fuel tank repair.

Exercises (442):

1. What happens when fuels come into contact with human skin?

2. Why is it necessary for you to wear cotton coveralls when you are working inside a metal fuel tank?

3. After removing street shoes and socks, when are you required to put on cotton socks when you are making internal fuel tank repairs?

4. What power tools are permitted inside fuel tanks?

5. What lights are authorized inside fuel tanks?

6. What must you remember if extension cords are required when you are making an internal fuel tank repair?

443. Classify the types of repair and repair procedures required for damaged fuel tanks and name the causes of structural repairs being needed for such tanks.

Usually a fuel system repairman inspects, seals, and performs most of the repairs associated with metal fuel tanks. However, when he finds metal damage beyond his repair capability, he will need your help. For example, you may have to install replacement rivets in stringer, ribs, bulkheads, webs, etc., in the tank to make it serviceable. And, if the damage is severe enough, a flush or nonflush patch may be required according to applicable TO instructions.

Damage Evaluations—External Fuel Tanks. Most of the repairs you perform on external metal fuel tanks involve skin repairs. Repairs to the internal members are less frequent, except in cases where a combination repair is required. Skin damages, such as cracks, holes, dents, and scratches are normally the main causes of structural repair to metal fuel tanks.

Minor dents and scratches are normally classified as negligible damage. You will find specific limitations concerning the depth and locations of the dents and scratches stated in the applicable-3 technical order. For instance, scratches are usually limited to a maximum depth of 20 percent of the skin thickness. Burnish out scratches within these limits. Likewise, dents are limited to a maximum depth of 0.03 inch, with a minimum length of 200X depth of dent. Also, the spacing between scratches should be no closer than 5 inches. The latter rule also applies to spacing between dents. In any event, scratches that exceed TO specifications are evaluated as cracks; whereas dents that exceed TO specifications are evaluated as holes.

You will find that all cracks and holes in the skin surface of metal fuel tanks require a patch. Such cracks may be repaired by welding. This repair does not apply, however, to those skins not manufactured from a weldable aluminum. In contrast, large cracks and holes will require a flush patch or nonflush patch, depending upon the applicable-3 TO guidelines.

Damage Evaluations—Internal Fuel Tanks. All damages to an internal fuel tank are classified as belonging in one of the four classifications of damages discussed in Chapter 2 of this volume. The repair procedures will depend on the structural member damaged. With the addition of sealant requirements, you can use the repair illustrations given in the applicable-3 TO for the damaged structural member. Information given in Chapter 2 of this volume will help you to perform this type of repair.

Exercises (443):

1. What are the main causes of structural repairs to external metal fuel tanks?

2. Minor surface scratches and dents are classified as what type of damage?

3. Scratches on an external fuel tank that exceed TO limitations are classified as what type of damage?

4. Dents on an external fuel tank that exceed TO limitations are classified as what type of damage?

5. State the types of damage classifications used for internal fuel tanks.

444. State the techniques, factors, and types involved and specific recommendations concerning the cutout of damaged areas and forcing out of dents on fuel tanks.

The repair procedures and tools used to perform structural repairs to metal fuel tanks are very similar to those used for nonflush tank areas. With this in mind, the following paragraphs are directed toward those repair techniques, factors, types, and recommendations associated with making a skin repair to an external metal fuel tank.

The repair procedures used will be directly related to the method used in fastening the repair parts to the fuel tank. In any event, when the repair parts are to be welded in place, removal of the damaged area and fabrication of repair parts are both responsibilities of the airframe repair specialist. Of course, in cases where rivets must be installed, your repair procedures will be more involved.

Cutout Requirements. You will be called upon to make two types of skin cutouts when you are repairing external fuel tanks. One type of for a welded repair and involves no repair parts; whereas the other type involves developing a cutout of a damaged area for a flush or nonflush repair.

Crack cutout techniques. When you believe a crack can be repaired by welding, prepare the edges of the crack prior to such welding. You can accomplish this by grooving the edges of the crack into a V shape. Use a rotary file for the shaping. The top width of the V-groove, the outer surface of the skin, should be approximately equal to the thickness of the skin being repaired. The length of the cutout should be extended approximately 0.125 inch beyond each end of the crack. This procedure insures that the crack is completely removed. Grooving the edges of the crack provides a wider surface area for the weld and permits the welded area to be grooved down for aerodynamic smoothness, without reducing the strength of the weld.

Damage cutout techniques. When a cutout is made for the installation of a repair part, follow the procedures we have discussed earlier concerning skin cutout techniques. Prior to starting the cutout process, You must consider the location of internal members. In work situations where the repair is to be welded in place, be sure that the corner radii is large enough to insure that all stress concentrations are eliminated. After the cutout has been completed, you must chamfer the edges of the cutout area. The width of chamfer should be approximately equal to the thickness of the skin being repaired.

When you use fasteners to fasten the repair in place, follow the general rules for determining the corner cutout radii required. NOTE: The edge of the cutout must *not* be chamferred.

Dent Removal Procedures. Two considerations dictate the procedures you will have to use in removing the dent: (1) the size of the dent and (2) whether you are able to get to the backside of the dented area.

Where access to the backside is possible, use a forming dolly and a plastic or rawhide mallet to hammer out the dent. Try to reshape the dented area with the least of amount of hammered blows. Why? Because excessive hammering will work-harden the area, and this will lead to cracks developing in the dented area. After the dent has been removed, inspect closely the reshaped area for cracks, especially the radii of the previous dent. In cases where small depressions remain, you can use an aerodynamic smoothing compound to return the area to aerodynamic smoothness requirements.

When access to the backside of a dent is not possible, you must use a dent pulling technique. This technique consists of drilling a hole in the center of the dent for installing a sheet metal screw. The size of the sheet metal screw should be as small as possible. Install the sheet metal screw leaving a clearance between the skin surface and screwhead. This clearance is necessary for attaching a pulling wire. After attaching a pulling wire—one usually made from safety wire—pull up on the wire, maintaining a constant pulling pressure. While maintaining the pulling pressure, take a plastic or rawhide mallet and lightly hammer along the radius of the dent. Once the dent has been removed, you can use a blind fastener, with proper sealing requirements to fill the screw hole. However, attempt this technique only on small dents. For larger dents a flush or nonflush repair must be installed, nased on applicable-3 TO guidelines.

Exercises (444):

1. What factor determines the repair techniques you will use when making a skin repair to an external fuel tank?

2. What types of skin cutouts are required when you are repairing the skin of external fuel tank?

3. How are cracks prepared for welding when you are repairing the skin surface of external fuel tanks?

4. What factors determine the size of a skin cutout that is to be welded?

5. What must be done to the edges of a skin cutout that is to have a filler plate welded into the cutout?

6. To what factor are the repair procedures used in removing dents from external fuel tanks directly related?

7. Why is it recommended that a dented area be reshaped with the least amount of hammering?

8. What can be used to restore the dented area to aerodynamic smoothness after a dent has been removed?

9. What size dents are removed using a dent pulling technique?

10. How should large dents be repaired, when access to the backside of the dented area is not possible?

445. Cite the factors, rules, procedures, and fastening method involved in fabricating repair parts for metal fuel tanks.

Parts fabricated for metal fuel tanks repair must be of the highest quality workmanship. Every effort must be taken to maintain TO tolerances. Accordingly, the methods used to fabricate repair parts discussed in earlier chapters of this volume will help you to meet the high standards required. Key factors, rules, procedures, and fastener method to remember when repairing each type of metal fuel tank are discussed in the following paragraphs.

External Tanks. When you are fabricating repair parts for external fuel tank repairs, you need to make sure that the repair materials used are of the same material, composition, and temper as the original tank material. Similarly, all filler plugs must be of the same thickness as the original material thickness. Also, the reinforcement plate—whether being used as a doubler or as a nonflush external patch plate—must usually be one gage thicker than the original material thickness.

Obviously, the shape of the repair parts must match the contour of the part being repaired. As for the size and number of repair parts required in any particular repair, these are determined by the part(s) being repaired, the amount of damage, and the fastening method being used. For example, welded repairs usually eliminate the need for doublers or splice angles. Again, a filler plug, which is welded in place, restores not only the contour requirement but also the strength requirements, thus eliminating the need for additional repair parts. Note, though, that the sides of a filler plug in a welded repair must be chamferred. Why is this necessary? Answer: So that when the filler plug is inserted into the cutout (which has chamferred edge), a V groove is formed around the cutout area. The width of the chamferred edge on the filler plug must be equal to the thickness of the filler plug.

Internal Tank. As we said earlier, internal fuel tanks are usually located within a main structural section of the aircraft. Therefore, repair parts must restore and in some cases, exceed the load-carrying requirements of the structural members used to form the internal fuel tank. In such cases, repair procedures given in the applicable-3 technical order must be closely followed.

Since, normally, all repairs accomplished to internal tanks will involve conventional fastening methods, you must give special attention to the fastener locations, fastener tolerances, and type of fastener used.

Exercises (445):

1. How should the filler plug for an external fuel tank compare with the original material?

2. What is the recommended rule to follow, considering the gage of the reinforcing plate used in external fuel tank repairs?

3. Why isn't a doubler required when a filler is welded into a cutout area?

4. What must be done to the filler plug that is to be welded in a cutout area?

5. What type of fastening method is almost always used in repairing internal fuel tanks?

446. Specify the factors and principles involved in installing repair parts for metal fuel tanks and give the reason for critical hole tolerances when nonrivet fasteners are used in such installation.

The final step in accomplishing a metal fuel tank repair is the installation of repair parts. The main factors that you must consider here are the fit of the repair parts, sealing requirements, and proper installation of the fasteners.

Fit. Not only do the repair parts restore the damaged area to its original contour, but they must also fit together as closely as possible. Thus, all drill chips and rough edges must be removed in order to obtain a close-mating surface contact. This contact reduces the gaps and voids which, if permitted, could lead to improper sealing of the repair area.

Sealing Requirements. At the same time that the repair restores the original contour and strength to the damaged area, it must also be leak-proof. You achieve this leak-proofing by installing seals, using various types of sealing methods, which are not covered here because an in-depth discussion of structural sealing is covered in the next section.

Fastener Installation. Obviously, fasteners used in fuel tank repairs must be carefully installed. After all, hole tolerances are very critical, especially when fasteners other than rivets are being used. Thus, a rivet shank will swell somewhat during installation, filling-in a slightly oversized hole. This is not the case, though, when fasteners such as Jo-Bolts, Hi-Locks, taper locks, bolt and nut combination, etc., are installed. You must follow closely proper techniques of pilot drilling, step drilling, and reaming, and to help you do this, you can find information on the proper drilling and reamer procedures outlined in the applicable-3 technical order. Remember, though, that riveting procedures must assure that the manufactured heads are flushed against the surface and that correct size shop heads are formed. So use the knowledges you have acquired in studying earlier chapters of this volume to remove, select, and install rivets.

Exercises (446):

1. What factors must you consider when you are installing fuel tank repair parts?

2. Why are hole tolerances very critical when fasteners, other than rivets, are being used to install fuel tank repair parts?

3. What techniques must you use to reduce the possibility of oversized fastener holes developing in fuel tank repair parts?

5-3. Structural Sealing

Certain areas of airframe structures are sealed compartments where fuels or air must be confined. Some of these areas contain fuel tanks; others consist of pressurized compartments, such as the cockpit. Since it is impossible to seal these areas completely airtight or watertight with a riveted joint alone, a sealing compound or sealant is used. Sealants are also used to add aerodynamic smoothness to external surfaces at seams and joints.

Three types of seals are ordinarily used. First of all, *rubber seals* are installed at all points where frequent breaking of the seal is necessary, such as canopies and access doors. In contrast, second, *sealing compounds* are used only for structural maintenance and part replacement at points where the seal has been broken, such as riveted lap and butt seams. *Special seals*, third, are required for passing cables, tubing, mechanical linkages, and wires out of pressurized or sealed areas. Wires and tubes are passed through pressure bulkheads by using bulkhead fittings such as cannon plugs for wiring and couplings for tubing. These fittings are sealed to the bulkhead, and the wires and tubes are fastened to them for each side. All seals of moving parts, such as flight controls, are subject to wear. Install them carefully and check them regularly.

447. Given a series of work situations requiring sealants, state the classifications of sealing level required and indicate the classification not calling for sealed seams.

Sealant requirements will differ, depending upon the area of the aircraft being repaired. What will be sealed and the type of seal required are based on the sealing level required.

Classification of Sealing Levels. The four basic types of sealing levels are as discussed in the following paragraphs.

Absolute sealing. An "absolute seal" is obtained when a compartment is sealed tight to permit no leakage. It requires the sealing of all seams, holes, slots, joggles, and structures which are fastened to the seal plane. All fasteners must be sealed if the seal is to be absolute.

Extensive sealing. An "extensive seal" is obtained when all holes, slots, joggles, and seams in the seal plane have been sealed. Here sealing is required for all bolts, screws, blind rivets, and repair rivets, except (1) pro-

Secondary seal. Sealant applied behind and in conjunction with primary sealing to confine liquid or pressurized air is known as "secondary seal."

Backup seal. "Backup seal" is a secondary seal which supports a primary seal.

Repair seal. A seal placed for the purpose of limiting the amount of sealing required to repair a leak is referred to as "repair seal."

Faying surface seal. A "faying surface seal" is a seal effected by the sandwiching of sealant between mating surfaces of assemblies.

Injection seal. You have an "injection seal" when dealing with the filling of holes or channels by the forcing of sealant into a void or cavity to obtain a primary or backup seal.

Fillet. This is a bead of sealant applied along structural junctions or seams.

Re-entrant fillet. A "re-entrant fillet" is an overlapping quantity of sealant not in close contact with adjacent sealant or structure.

Top coat. The "top coat" is, of course, a continuous film of material which provides sealant protection from fuel and corrosion protection for metal surfaces.

Tack-free time. That point of time in the curing of a sealant or top coat at which the material does not stick when a dry knuckle is pressed lighty against the sealant or top coat and withdrawn is spoken of a "tack-free time."

You can obtain clarification of additional terms and expressions to the foregoing by looking into Section II, of TO 1-1-3, *Preparation Inspection and Repair of Aircraft Fuel, Oil and Water Alcohol Cells and Intergral Tanks.*

Exercises (448):

1. In the space provided in front of each definition in column A, place the number of the term given in column B which matches the definition. Note: Each item in column B matches once or not at all.

Column A	*Column B*
___ a. Internal curing agent for sealants.	1. Primary seal
___ b. A bead of sealant applied along structural junctions or structure.	2. Secondary seal
___ c. A seal effected by the sandwitching of sealant between mating surfaces.	3. Top coat
___ d. Sealant applied to structure which becomes a part of the seal plane.	4. Accelerator
___ e. The major component of sealant material.	5. Seal plane
___ f. Sealant forced into a void or cavity to obtain a primary or backup seal.	6. Faying surface seal
___ g. That which protects sealant from fuel.	7. Fillet seal
	8. Backup seal
	9. Base compound
	10. Injection seal

2. What technical order contains clarification of sealant terms and expressions?

449. Cite specific details of the procedures used to inspect and remove defective sealant seals and give the steps in resealant removal.

Sealant Defects. Pressure tightness of an area of section is checked before and after a repair is made. Ground pressurization is accomplished by filling the section with air from an external source through ground pressure testing fittings.

With the section pressurized to a given pressure, you may locate leaks on the outside of the aircraft by applying a soapless bubble fluid to all joints and seams in the suspected area. Air bubbles will clearly pinpoint for you the general area of the leakage. You may also isolate a specific leak on the inside of the aircraft by passing the free end of a stethoscope, or a similar listening device along the seams in the leakage area. When you do this, you can detect the leak by the change in sound when the instrument passes over it. After completing the test, remove the soapless bubble fluid from the outside of the aircraft by washing the surface with clear water to prevent corrosion.

Precautionary measures. Here are a few precautionary measures you should follow during the testing procedure:

a. When there are personnel inside the area, *never* pressurize it to a pressure higher than has been previously established during testing with the section empty.

b. Do not allow any person who has a cold or who has recently had one, or whose sinuses are imparied in any way to work inside the pressurized section.

c. Have a qualified operator present at the pressurization equipment control panel at all times while the section is being pressurized. If the cockpit is being pressurized, have all personnel stand clear of the canopy.

Necessary repair or replace conditions. Pressurization may not always be necessary to determine sealant defects. Indeed, you should see that sealants are either repaired or replaced when the following conditions are present:

a. Sealant is peeled away from the structure.
b. Seams are exposed through fillet seal.
c. Fillet or hole filling sealant is exposed through coating.
d. Sealant is damaged because of removal and installation of fasteners, access doors, or other sealed parts.
e. Crack or abrasions exist in the sealant.
f. Air bubbles appear in the sealant (air bubbles will expand at high altitude, resulting in damage to the seal).
g. Leakage occurs between sealed faying surfaces.

Sealant removal. When engaged in sealant removal and fairing be sure that the tools you use are locally manufactured. They should be of the sizes and shapes shown in figure 5-9. The materials used in their manufacture should be hardwoods, with metal as an alter-

truding head rivets, (2) standard flush rivets in dimpled holes, and (3) standard flush rivets in countersunk holes, if driven high and shaved.

Intermediate sealing. An "intermediate seal" is obtained when all holes, joggles, seams, and slots in the seal plane have been sealed. Here fasteners do not require sealing.

Limited sealing. A "limited seal" is obtained when all holes, slots, and joggles in the seal plane have been sealed. Seams and fasteners do not require sealing when this sealing level obtains.

Environmental Sealing Types. Sealing is further grouped according to the type of environment encountered. Thus the eight types described in the following paragraphs exist. Each of these types may be placed within one of the four sealing classification levels that follow.

Fuel sealing. "Fuel sealing" is used to confine or control either liquid fuel or fuel vapor within a defined area. In a fuel-sealed area, the sealant must be fuel resistant. For example, liquid fuel sealing falls into the absolute sealing classification; whereas fuel vapor is classified as intermediate sealing.

Pressurized area sealing. "Pressure sealing" is used to maintain a required pressure within a defined area. This is an allowable leakage type of sealing; however, proper application of sealants should keep leakage small enough so that correct cabin pressure can be maintained at high altitude. Note that while "cabin area sealing" falls into the extensive sealing classification, "aerodynamic balance sealing of the empennage" is classed as limited sealing. In further contrast, "aerodynamic sealing area in the wing" is classified as intermediate sealing. In pressure-sealed areas, the sealant is always applied to the pressure side of the structure.

Weather sealing. "Weather sealing" is used to insure adequate protection from moisture, dust, and rain. It generally falls within the intermediate level. The entire exterior surface of the aircraft is sealed by application of aerodynamic smoother, which is applied to all skin joints and fasteners. However, various compartments and doors, particularly those found along the upper fuselage surface, are sealed internally.

Firewall sealing. "Firewall sealing" is used to restrict the passage of flames through the seal plane. This type is classified as absolute, intermediate, and limited, according to the area where it is used. Materials used for this type of sealing are exceedingly critical.

Electrical sealing. "Electrical sealing" is used to prevent leakage of fuel, fuel vapor, or pressurized air from a sealed area; to prevent fuel or fuel vapor from entering connectors and compartments where arcing might occur; and to prevent dust and water from entering connectors and electrical components,thus causing corrosion. Materials used for this type of sealing are dependent upon the environmental location of the seal.

Acid-resistant sealing. "Acid-resistant sealing" and acid-resistant finishes are used to prevent any corrosion solution of battery electrolyte or uric acid from contacting the structure. Acid sealing is classified as absolute sealing.

Window sealing. "Window sealing" is a combination of pressure sealing, weather sealing, and aerodynamic smoothing.

High-temperature sealing. "High-temperature sealants" must be used in those areas where operating temperatures exceed 93° C. (200° F.). These include engine pods, anti-icing ducts and adjacent structure, engine air bleed lines to air conditioning turbines, and areas adjacent to various electronic equipment.

Exercises (447):

1. In the space provided in front of each type of sealant requirement, place the classification of sealing level required:
   _____ a. Weather sealing.
   _____ b. Fuel vapor sealing.
   _____ c. Liquid fuel sealing.
   _____ d. Cabin pressurized sealing.
   _____ e. Acid sealing.

2. Which of the classifications of sealing levels does *not* require that seams be sealed?

448. Associate a series of sealing terms with their definitions and state the TO clarifying sealing terms and expressions.

Sealing Terms. As an airframe repair specialist, you need to be familiar with those sealing terms commonly used to describe materials and procedures for maintaining general aircraft sealing. For that reason, the following list is given.

Sealant. This is a mixture of base compound and accelerator used to cure a firm fuel-, acid-, or water-resistant material.

Accelerator. "Accelerator" is an internal curing agent for sealants.

Base Compound. The major component of sealant material used with accelerator to produce a fuel-, acid-, or water-resistant sealant is called "base compound."

Seal Plane. This refers to the interior surfaces of a tank, tank cavity, or pressurized compartment—comprized of structure, integrally sealed fasteners, and sealant—which actually contains the liquid or pressurized air.

Primary seal. The "primary seal" is that sealant applied to a structure which becomes a part of the seal plane.

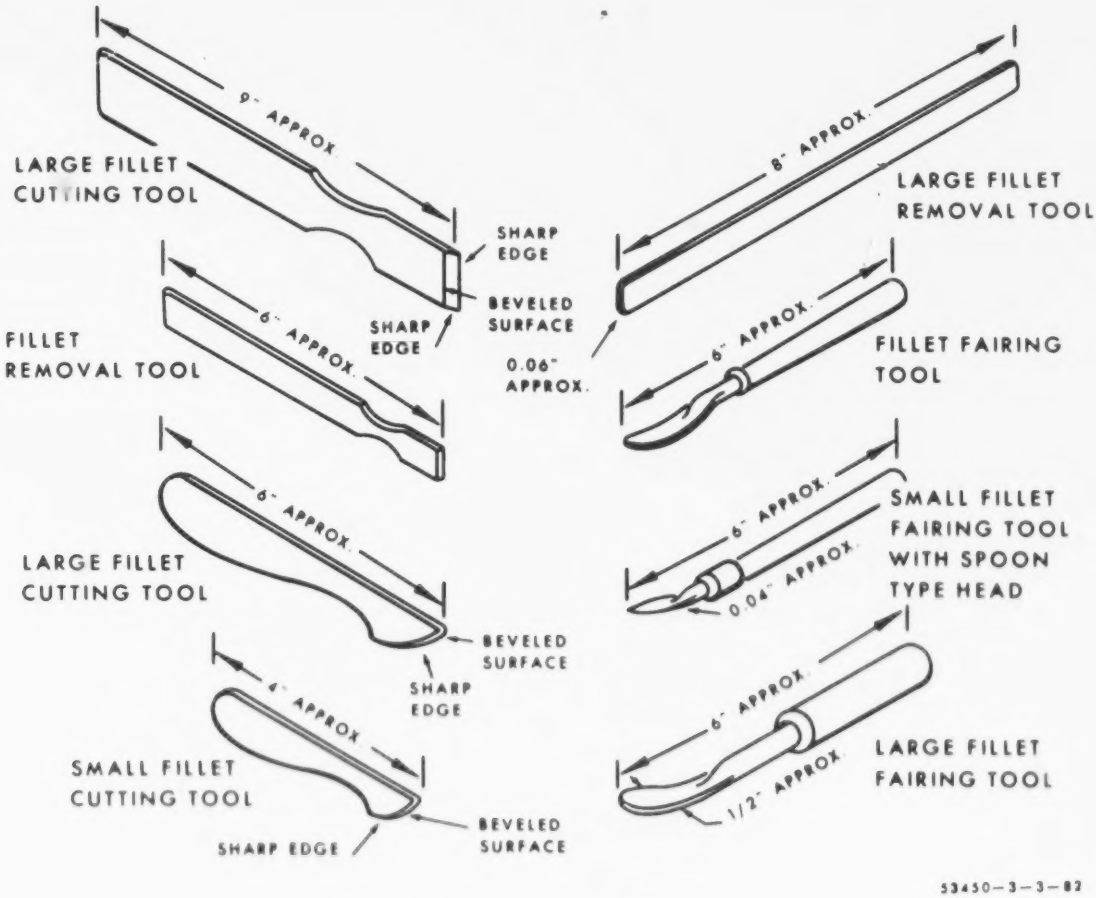


Figure 5-9. Seal removal and filler fairing tools.

nate and least recommended material. No tools you use should be made of a material harder than 2024–T3 aluminum alloy, and those of this alloy must be used with care. Do not use plastic scraper to remove defective sealant, since most plastics generate static electricity. Select the proper tool to be used according to the job that is to be done. Ingenuity will help you in the selection of the proper tool for the job at hand. Note that the tools shown in figure 5-9 are those currently used in sealing maintenance work.

Fillet removal procedures. Repair defective fillet seals by removing the faulty sections from the fillet and applying new sealant. You can remove the fillets as follows:

a. Select the proper sealant cutting tools—ones similar to those shown in figure 5-9.

b. Cut the faulty section from teh fillet.

c. Cut scarfs at the ends of the section, so that new sealant will overlap the remaining portions of the old fillet seals in these areas. Avoid abrupt changes in the cross section. Remove enough sealant on both sides of the defective area to be sure that the remaining material is satisfactory.

d. Examine all cut surfaces and remove loose cuts or flaps. Certainly, make sure that no faulty sealant remains. Also, of course, if the old fillet adjesion is still good, it is not necessary for you to cut the sealant to the are metal.

Resealant removal procedures. Remove resealant around the fasteners as follows:

a. Use a sharp cutting tool to cut around the seal and at the base of the fastener in order to separate the sealant from the structure. If the fastener is cap-sealed, work the tool under the edge of the seal cover.

b. Grasp the seal or cover with a pair of pliers and pull it away from the fastener end. You can remove most of the seal by this process.

c. Carve away the remaining sealant with cutting tools.

Exercises (449):

1. What material is used during pressure-testing to locate leaks on the outside of an aircraft?

2. How are specific leaks isolated on the inside of aircraft during pressure-testing?

3. Why must sealant be replaced which contains trapped air bubbles?

4. What is the hardest material that can be used to fabricate sealant removal tools?

5. Why is it recommended that sealant removal tools not be fabricated from plastic?

6. Why are the ends of a fillet seal cutout area scarfed?

7. Why should a sharp cutting tool be used to cut around the seal and the fastener's base?

450. Supply specific factors and safety precautions considered in the cleaning of a surface for sealant application.

Obviously, a surface that is to be sealed must be cleaned immediately prior to the applications of the sealing compound. Why? Simply because sealant will not adjere to a surface which has not been cleaned completely. Many types of impurities form a film on the surface—one which is not visible but which prevents proper adhesion of the sealant.

Remove all chips and foreign materials from the areas to be sealed. Thoroughly clean these areas and all metal in adjacent areas, using methy ethy ketone (MEK). To do this, begin at the top of the areas to be sealed and work downward, using a clean, lint-free cheesecloth pad saturated with the cleaning solvent. The solvent will float oil, grease, dirt, etc., to the surface, making it easy for you to remove this by wiping the surface with a dry, lint-free cheesecloth. Note, however, that you must not allow all of the solvent to evaporate from the surface before wiping it, because then some or all of the oil, dirt, etc., will be redeposited on the surface, where you cannot remove it with a dry cloth. Remember, too, that you should never dip the pad into a fresh supply of solvent. Instead, always pour the solution onto the cheesecloth. Why? To avoid contamination of the solvent with the oil or dirt which the cloth may have collected. Use a stiff bristle brush to enable you to clean more effectively around bolts, rivets, etc. Of course, you should use a clean piece of cheesecloth as you work with each new area to be cleaned.

During the whole cleaning operation, always provide adequate ventilation, since cleaning solvents are toxic and flammable. Also, never use an excess amount of any cleaner and do not touch the area with your fingers. The reason for this is that oil from your skin will leave a film on the metal, making it difficult to impossible for the sealant to adhere properly. You must continue the cleaning process until there is no discoloration on the clean drying cloth you are using.

Exercises (450):

1. Why is it very important that a surface to be sealed must be completely clean?

2. What type of cleaner is usually used to clean a surface to be sealed?

3. Where should you start cleaning a surface to be sealed?

4. Why is it important for you not to allow all of the cleaner to evaporate on the surface?

5. What must you do to keep from contaminating the cleaning solvent while engaged in the cleaning process?

6. At what time is the cleaning process completed?

7. Why must you never touch a surface that has been cleaned for sealing?

8. What safety precautions must you follow when you are using cleaning solvents?

451. Give specific procedures related to the storage and preparation of sealing compound and define "Semkit."

The handling of sealing compound is critical. Consequently, you should store, mix, and use sealant according to specific directions. What directions? Answer: First, always check applicable technical order instructions. Then, second, follow them exactly. Deviations from accepted procedures are not permitted, since poor sealing can cause the loss of both the aircraft and its personnel. Your close surveillance of material worklife and cure time is an absolute requirement.

Storage of Sealing Compound. You will find storing instructions for sealants given by the manufacturers and contained in technical manuals. Here, since age limits are established, you should check all "out dated" sealants prior to using them. Question: What is a satisfactory check for "out dated" sealants? Answer: mix a container of base material with its accelerator at room temperature; then determine the time required for a sample aplication to become tack-free. Compare this actual time with the corresponding maximum allowable tack-free time given in the applicable TO specification. If the time you have obtained exceeds the maximum allowable, you should discharge the sealant.

The normal storage life of MIL-S 8802 sealant is 9 months. However, temperatures above 80° F. may reduce this storage life. Also, unmixed sealant is not adversely affected by freezing. In any case, after 9 months you must test the sealant with the possibility in mind of extending its storage life. If, on testing, you find a sealant that meets tack-free requirements, stamp it *"DATE TESTED"* and *"DATE FOR RETEST"*. Sealant may be updated 1/3 of its shelflife at each test or retest. Of course, if you find sealant that does not meet the tack-free requirement, you should discard it. Most sealant should be stored at temperatures between 50° to 80° for best results.

Sealants are obtained generally in two types—(1) one being a two-part sealant, with accelerator and base compound combined. Some of these are of the brushable type (i.e., can be applied with a brush). The (2) other type of sealant is a one-part material (high temperature and firewall sealant). It is compounded by the manufacturer and ready for you to apply as packaged.

With either type, when you wish to store mixed (activated) sealants, place them inside containers and cover them to prevent contamination of them. Label each container with the class of sealant and the time and date of mixing.

You can quick freeze sealant by placing containers of it in a refrigerated box at approximatley -40 to -130 degrees for a minimum of 20 minutes. You may then store the quick-frozen sealant at 0° F. or colder for the time specified in the applicable technical manuals. The time consumed by freezing, storing, and thawing operations reduces the total worklife of such sealants by approximately 45 minutes.

To thaw frozen sealant employ one of the following methods:

- Allow the sealant to set at room temperature for approximately 20 minutes, or until the sealant is soft. You may blow compressed air over the container to effect thaw.
- Insert container in 120° + 5° Fahrenheit water bath for approximately 4 minutes.

NOTE: Do not use heat to accelerate the thaw. Also, do not use sealant if it is grainy or stringy after having been thawed.

Preparation of Sealing Compounds. You must not mix the brushable type sealant before you are ready to use it, because it has a worklife of only 2 hours at 21° C. (70° F.) When you use sealant, keep it covered it possible, because the worklife decreases when the sealant is used from an open can. You must not add any thinner to one-part compounds after the sealant starts to thicken. Why? Because, as the material thickens, it becomes harder to brush on and thus makes a smooth job impossible. When this occurs, discard any remaining sealant. Remember, too, to clean all sealing guns and nozzles in methy ethyl keton, Specification TT-N-261, before the end of the worklife of the sealant.

As we have already said, one-part materials (high-temperature and firewall sealant) are compounded by the manufacturer; they are ready for you to apply as packaged. However, if you want to thin this sealant, use thinner of the same type as that used by the manufacturer. When mixing two-part materials (i.e., all other sealants), mix the base compound with the matched accelerator in the proportions recommended by the compound manufacturer's instructions. Mix sealant using the following procedures:

(1) Weigh correct amounts of the base compound and the accelerator in clean, wax-free containers immediately prior to mixing them. Control the scales and weighing procedure within 2 percent to insure good quality sealant.

(2) Mix the components until the color is uniform, and do not whip air into the sealant.

(3) Transfer the sealant into another clean container and complete the mixing, or—alternately—mix the sealant on a clean flat plate, using a spatula.

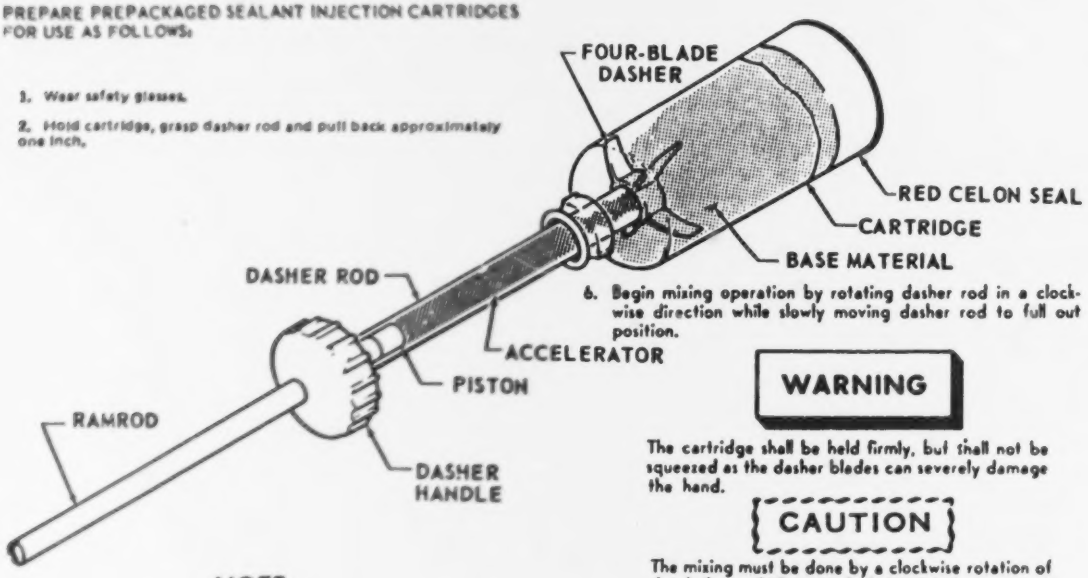
(4) Pour the sealant into a clean polyethylene gun tube or clean friction-top can. Remember, here, to label the tube or container with the name and number of the sealant, the date, the time of mixing, and the worklife expiration date and time.

You will find certain types of sealants, such as MIL-S-8802, available as kit sealant (Semkit). This kit is a compact two-part mixing and application unit designed for easy mixing and proper application of the sealant in small quantities, as shown in figure 5-10. The base sealant is packaged in standard 2½- and 6-ounce cartridges which you can place in a filleting gun or injection gun for application. In using this method, note that the handle or dasher contains premeasured

PREPARE PREPACKAGED SEALANT INJECTION CARTRIDGES FOR USE AS FOLLOWS:

1. Wear safety glasses.

2. Hold cartridge, grasp dasher rod and pull back approximately one inch.



NOTE

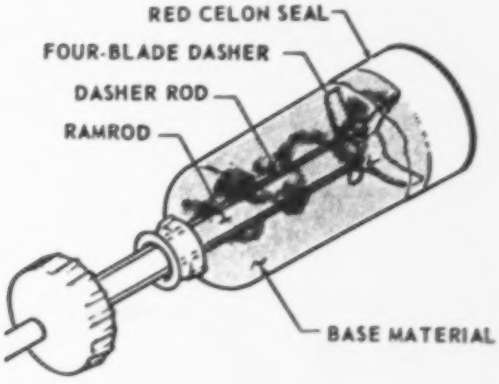
Use even pressure, do not use force, tap, pound or jolt ramrod if piston does not break loose readily.

3. Insert ramrod into hollow of dasher rod, break piston loose and inject about 1/3 of the contents into the cartridge.

NOTE

The ramrod will be fully inserted into the dasher rod when all of the accelerator has been forced into the cartridge.

4. Repeat steps 2 and 3 until all of the contents of the rod are emptied into the cartridge. Then remove ramrod.



5. Remove and discard ramrod.

6. Begin mixing operation by rotating dasher rod in a clockwise direction while slowly moving dasher rod to full out position.

WARNING

The cartridge shall be held firmly, but shall not be squeezed as the dasher blades can severely damage the hand.

CAUTION

The mixing must be done by a clockwise rotation of the dasher rod. Counterclockwise rotation must not be used because the four-blade dasher inside the cartridge will unscrew from the dasher rod.

7. Continue clockwise rotation and slowly move dasher rod to fully in position.

CAUTION

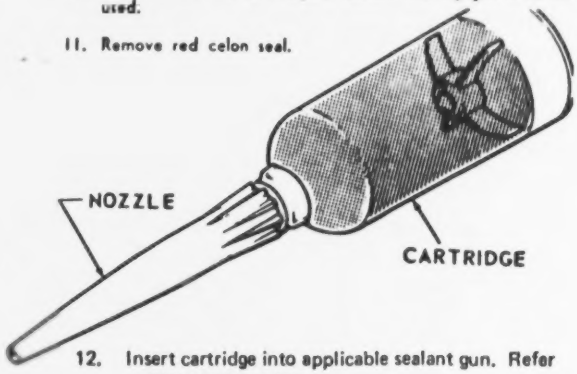
A minimum of five full clockwise revolutions must be made for each fully out stroke and for each fully in stroke of the dasher rod. Mix material for the number of strokes recommended by the material manufacturer in their mixing instructions.

8. End mixing action with dasher rod in full out position.

9. While holding cartridge in an upright position, unscrew dasher rod by gripping dasher blades in area of red celon seal and turning dasher rod counterclockwise.

10. Screw nozzle into cartridge if sealant filleting gun is to be used.

11. Remove red celon seal.



12. Insert cartridge into applicable sealant gun. Refer to SEALANT GUNS

Figure 5-10. Hand mixing of sealant kit.

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catalyst, and this should be so retained until the ramrod has been applied to release the seal at the bottom of the dasher.

Exercises (451):

1. When would you conduct a tack-free test?

2. What is the normal storage life of MIL-S-8802 sealant?

3. How long can you increase the shelflife of a sealant if it passes the tack-free test?

4. Most sealants give best results when they are stored within what temperature range?

5. What is the normal worklife of brushable type sealant?

6. What type of cleaning solvent should you use to clean sealing tools?

7. What is a "Semkit"?

8. What type of container should you use to mix a two-part sealant compound?

9. What is the effect of the time consumed by freezing, storing, and thawing operations on the worklife of a sealant?

10. If a sealant meets the tack-free requirements, what must you do to the sealant container?

452. Differentiate among the seal types used in applying sealant compound and cite specified application procedures related to sealants, to blind bolts, to work near uncured sealant, and to fillet seals.

Various types of seals are used to produce a sealed area, obviously. Each of these types has a definite place where it is to be used. The following paragraphs describe these types and tell their uses. They cover, in order, faying surface sealing, fillet sealing, injection seals, and fastener seals.

Faying Surface Sealing. This type of seal, pictured in figure 5-11, is applied, as we have said earlier, between the contacting surfaces of two or more parts. In some instances, this type is used to produce a block-off seal, to effect a seal between parts where a fillet seal would mean extensive sealing and where the assembly sequence restricts the use of fillet seals. Two types of faying surface seals exist: (1) removable and (2) permanent. The removable type is used around access doors, removable panels, inspection plates, windows, etc. The permanent type is used between parts of a structure that is permanently fastened together.

Faying surface sealing is, as we've earlier mentioned, the application of sealant between mating surfaces of attached parts. To accomplish this, coat one surface with sealant before assembling the parts. Be sure to apply enough sealant to form a bead of excess sealant along the joint after assembly. Assemble the parts while the sealant is freshly mixed.

Fillet Sealing. The fillet, or seam seal, shown in figure 5-12, is, you'll recall, a primary seal and the most common type found on an aircraft. Note again that fillet seals are used to cover structural joints along stiffeners, skin butts, walls, spars, and longerous and to seal around fittings and fasteners. Also, this type is the most easily repaired and the most efficient seal that can be produced.

You make a single application of sealant, using a sealing gun shown in figure 5-13—the Semco Model 250 (Pyles Industries, Inc., Detroit, Michigan) or its equivalent—to attain the structural size illustrated in figure 5-14, 5-15 and, 5-16. These figures are examples showing the width and the height of sealant to be maintained always as per the applicable TO). These measurements try to illustrate for you an example of those found in the TOs. Note here that the nozzle tip must be pointed into the seam and maintained at a 45° angle to the line of travel, forcing the bead of sealant to precede the gun tip to minimize entrapment of air. You must work fillets into seams with fairing tools. Such tools, shown earlier in figure 5-9, enable you to work the sealant into seams and to level and smooth the sealant after the application is completed. Remember, you must avoid air bubbles as much as possible during this operation. Allow the sealant to cure to at least the tack-free stage before moving the assembly.

Injection Seals. This type of seal, pictured in figure 5-17, is used primarily to produce continuity between seals. When fillet seals have reached a point where they can no longer be applied in a continuous line, use an injection seal to produce this continuity. This seal goes through joggles, gaps, openigns, etc. You can also use it where the structure is so designed that the compound

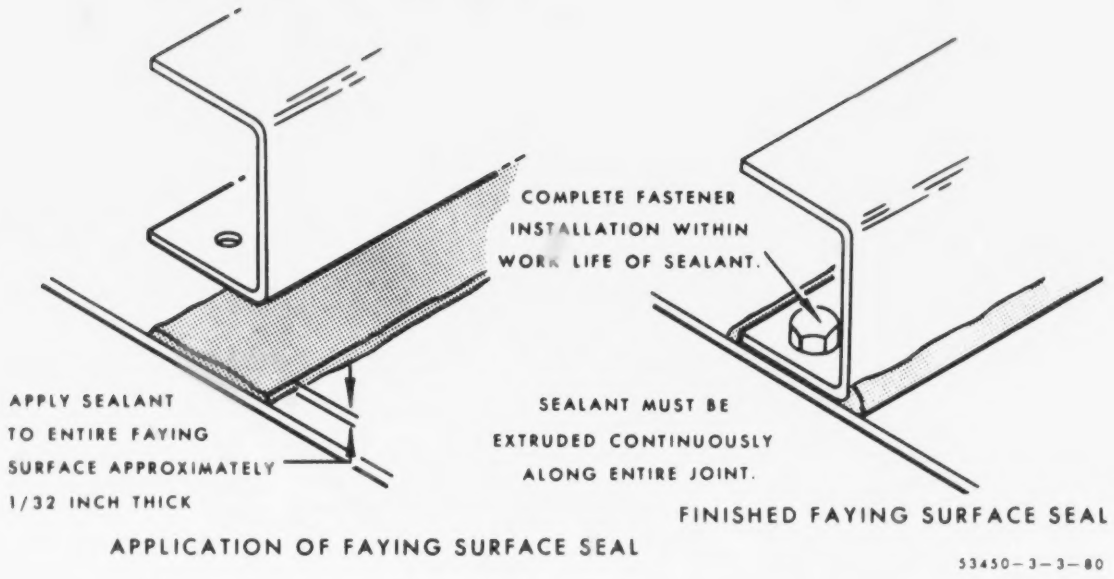

Figure 5-11. Faying surface sealing.

has to be forced into an area to make contact with certain parts.

Injection sealing seals voids, such as those that occur in corners and in areas adjacent to structures. But you, should clean the voids of all dirt, chips, burrs, grease, and oil before you do the injection sealing. Use a drill of approximately the number 32 size to drill the necessary number of holes into the void. NOTE: Never drill into the structure behind the void—*only* into the void. Drill holes one at at time or as necessary to permit the proper injection of the sealant. Apply the sealant to all confined holes, slots, and joggles until sealant is extruded at all openings to the confined area. For hard-to-reach areas, attached a length of plastic hose to the pressure gun tip. Do the filling by forcing sealant into one end of a cavity or injection hole with a sealant injection gun, like that shown in figure 5-18, until the sealant emerges from the prescribed area. Figure 5-19 illustrates typical areas requiring the injection type of sealing.

Fastener Seals. Figure 5-20 illustrates techniques used to seal different types of fasteners. Fasteners are sealed either during assembly or after assembly. To seal *during* assembly, apply the sealant to the hole or dip the fastener into sealant. To seal *after* assembly, cover the *pressure* side of the fastener with sealant. When fasteners are installed through faying surfaces, the sealed parts do not need additional sealing unless overcoating is required.

When possible, insert all nonflush head bolts which pass through fuel tank boundaries from the inside of the tank. Before inserting the bolt, clean thoroughly to remove all oil, dye, etc., and apply a small bead at and around the shoulder of the bolt with sealant. Do not seal any bolts until they have been torqued to correct *valves,* because torquing during or after sealing is *not* allowed. Final torque must be completed before the end of the sealant worklife.

Rivet sealing procedures. To seal rivets, proceed as follows:

a. Clean the rivet and immediate area with a cleaner, such as MEK.

b. Using a little sealant at a time, brush it into the base of the rivet. Do not lay it on the rivet.

c. Make a continuous seal around and over the rivet.

d. Apply enough sealant to form a fillet thickness at the junction of the shop head with the structure.

e. Allow no voids or air bubbles in the seals.

f. Let the job cure until it is tack-free.

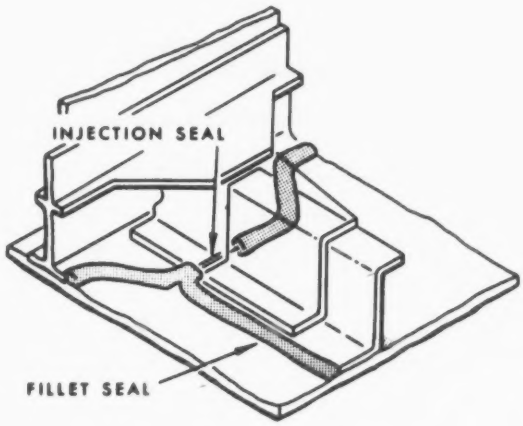

Figure 5-12. Typical fillet seal.

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3 GUN MODELS

*250-2-1/2 . . . . . 2-1/2 OZ CAPACITY
250-6 . . . . . 6 OZ CAPACITY
250-12 . . . . . 12 OZ CAPACITY

ALL PARTS INTERCHANGEABLE

NOTES:

1. Plastic Cartridge and Steel Safety Retainer Determines Capacity. All other Parts are identical.
2. Total Weight (6 Fl Oz Gun) -15 Oz
3. Length Overall Less Nozzle (6 Oz Gun) - 8-1/2".
4. Pistol Grip Handle May Be Removed to Convert to Lever Throttle For Confined Areas.

*5. 2-1/2 Oz Capacity Recommended for Most Field Repairs.

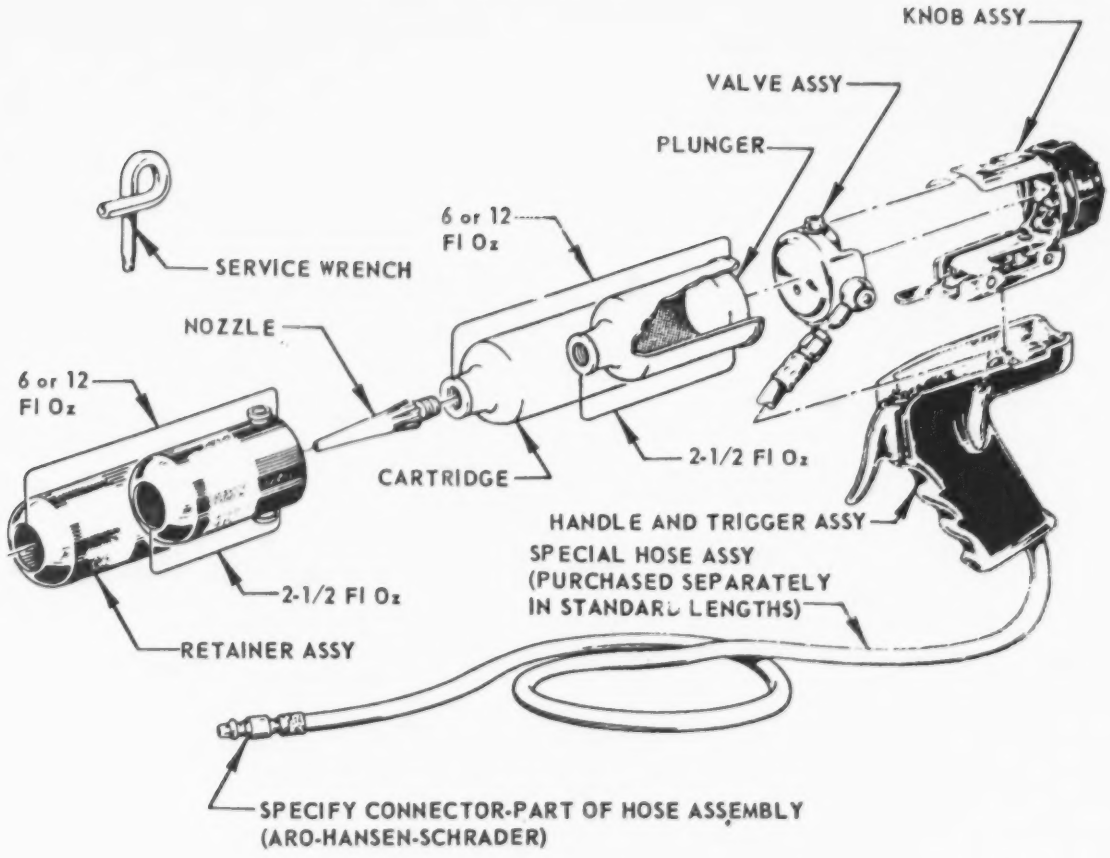
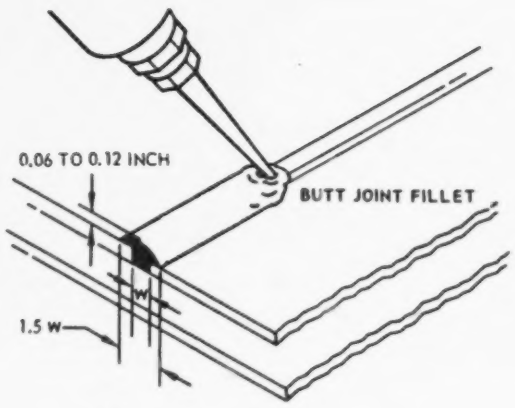


Figure 5-13. Filleting gun.



NOTE
W = 0.25 FOR DUCT AND PRESSURE SEALING
W = 0.50 FOR WEATHER SEALING

Figure 5-14. Application of butt joint fillet seal.

Fastener replacement procedures. When it is necessary to replace a loose fastener that extends in a fuel tank, proceed as follows:

a. Have the fuel tank depressurized and drained to level below the leaking fastener.

b. Remove the leaking fasteners from the fuel tank exterior. Be very careful to avoid damaging the fastener hole and, if applicable, the countersink, because effective sealing depends upon a good hole.

c. Select the proper size and type of blend bolt, such as a Jobolt, for the repair, taking into consideration the diameter, grip length, and head style needed.

d. After having removed the leaking fastener, clean the fastener hole with a cleaning solvent, such as MEK.

e. Disassemble the blind repair bolt; it is comprised of a screw, a sleeve and a nut, as shown in figure 5-21.

f. Clean each part of the repair bolt assembly.

g. With the repair bolt still disassembled, apply sealant to the screw, making sure that all of the threads and the underside of the head of the screw are coated.

h. Reassemble the blind repair bolt.

i. Apply sealant to the shank and the underside of the head of the nut and to the shank of the sleeve.

j. Install the blind repair bolt.

k. After having installed the blind repair bolt and having removed the breakoff portion of the screw, make sure that the recess in the head of the nut is filled with sealant.

l. If time is critical, cure the sealant by applying heat to the area.

Always consult the applicable section of the -3 technical order for the correct type of sealant to use in any application. Also given are the thickness and type of seal required for the various sections of the aircraft. Since materials, type, and application procedures vary with different models of aircraft, you must use different methods of application to properly seal different areas of the structures. However, in *any* type of application to *any* area of a structure, do not allow the recently sealed areas to become contaminated with foreign material. Also, do not allow the fresh, uncured sealant to be dislodged by jarring or vibration. If it is necessary for you to work near or on the repaired part before the sealant is cured, use a cloth-back tape to cover the sealant. This procedure will prevent damage and keep foreign materials off the sealed area.

Exercises (452):

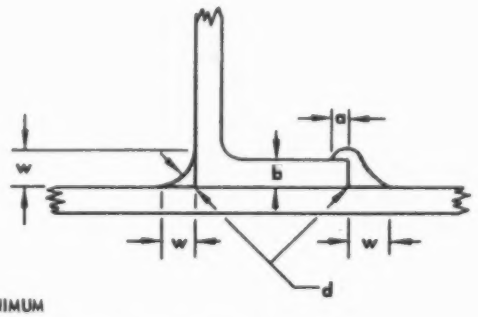
1. What type of seal is applied between the contacting surface of two or more parts?

2. What type of seal is found most often on an aircraft?

3. What type of seal is the most efficient seal that can be produced?

4. Continuity between seals is produced by what type of seal?

5. To which side of an installed fastener should you apply sealant?



NOTE
d = .15 MINIMUM
w = .25 MINIMUM
a + b = w, EXCEPT a = 0 WHEN b IS GREATER THAN .25

Figure 5-15. Structural dimensions of fillet seal.

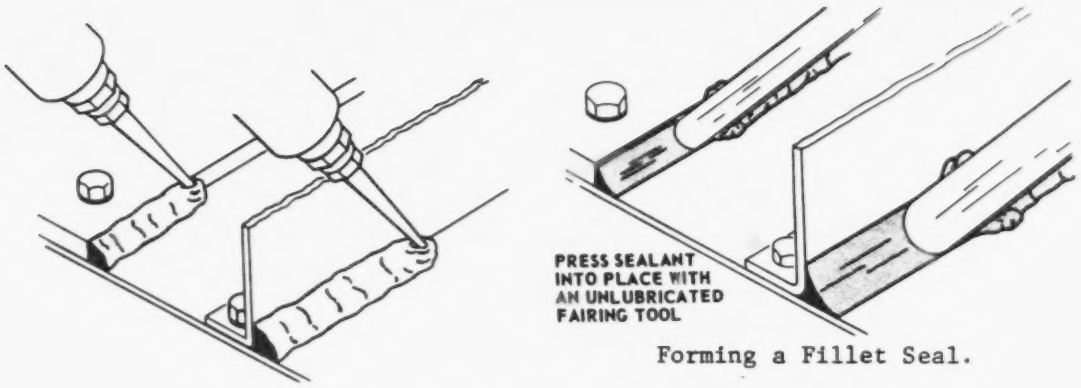


Figure 5-16. Application of fillet seal.

6. When should you apply sealant to a standard bolt used in repairing an internal fuel tank?

7. What must be done to a blind bolt prior to your installing it into a fuel tank?

8. If it is necessary for you to work near or on the repair part before the sealant is cured, what must you do?

9. When applying a fillet seal, how should you position the nozzle tip and in what direction should you apply the sealant?

10. After applying sealant, how long should you wait before moving the assembly containing the sealant?

453. State specific factors that influence the cure rate of sealing compound and state those aircraft areas where sealant with isopropyl alcohol should never be used.

Sealing Compound Curing. The length of time required to cure sealant is dependent upon three factors: (1) the worklife of the sealant, (2) the ambient temperature, and (3) the relative humidity. For example, high temperatures and high humidities shorten the cure. In contrast, a long worklife sealant requires a longer curing period than does a short worklife material. Again, cure may be accelerated by using heat, but sealant temperature should not exceed 49° C. (120° F.) Such heat may be supplied by hot-air blowers, by heat lamps, or prewarming the structure. Furthermore, the addition of water vapor to raise the relative humidity to approximately 60 percent (the maximum advantage is reached at 60 percent relative humidity) will shorten the cure life of a two-part sealant. However, heating alone is not always effective or practical. For example, if the aircraft is outside, and ambient temperatures is between 10° and 21° C. (50° or 70° F.), any one of the following additives, when added to certain sealant materials, will accelerate the cure:

- Isopropyl alcohol, Specification MIL-F-5566. This may be added during mixing in proportions not to exceed 3 percent by weight of the base compound. This particular mixture will craze acrylics.

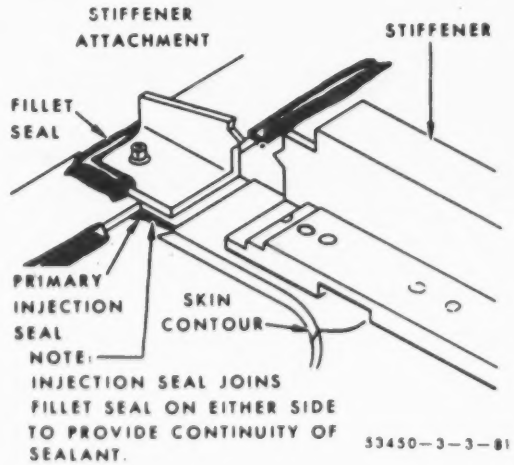


Figure 5-17. Typical injection seal.

OPERATION OF SEALANT INJECTION GUN.

1. Determine material to be used in accordance with instructions for repair being performed, and prepare mixture as required.
2. Detach the gun nozzle from the gun barrel, and detach the gun barrel from the coupling.
3. Remove cartridge plunger and drill a 3/8-inch diameter hole through its center.
4. If attached, remove the nozzle of the cartridge.
5. Slip gun plunger through drilled hole in cartridge plunger.
6. Pour mixture into cartridge.
7. Carefully extend gun plunger through filled cartridge, making sure gun plunger extends completely through cartridge and cartridge plunger is properly seated against mixture in cartridge.

CAUTION

The gun plunger is apt to become damaged during operation if not extended completely through the cartridge.

NOTE

The cartridge plunger must be firmly seated against the mixture to insure removal of trapped air in the mixture.

8. Attach the gun barrel to the coupling and attach the gun nozzle to the gun barrel.
9. Attach the unit to the air motor and hand-tighten all parts of the gun.
10. If required, attach injection tip to gun nozzle.
11. Attach gun to air source of 100- to 120-pound air pressure.
12. Depress trigger intermittently to operate gun.

NOTE

A small amount of mixture (approximately 6 grams of MIL-S-8802 sealing compound) is ejected with each depression of the trigger, and the gun must be operated slowly to allow the gun nozzle to refill after each ejection.

13. After injecting mixture, immediately disassemble the gun, remove the cartridge, and clean the gun parts.

NOTE

If cleaning proceeds immediately after use, the mixture remaining in the gun can be removed easily with compressed air. Dried mixture can be removed by carefully scraping the gun parts.

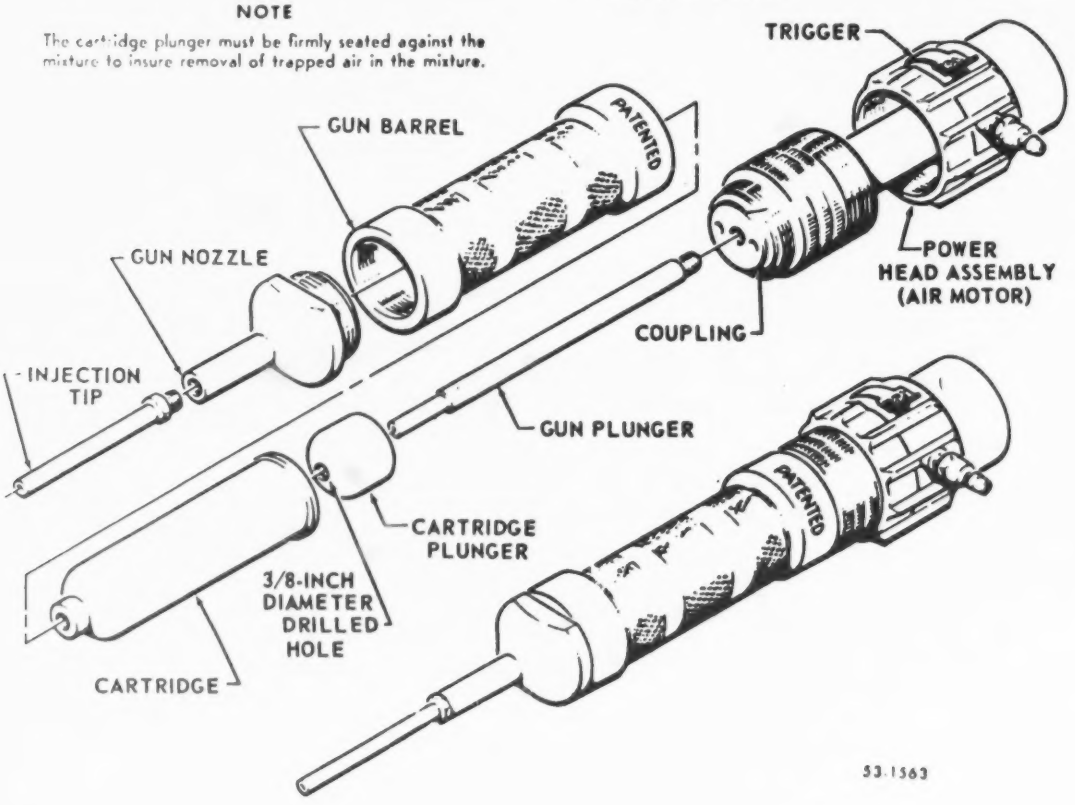


Figure 5-18. Sealant injection gun and its operation.

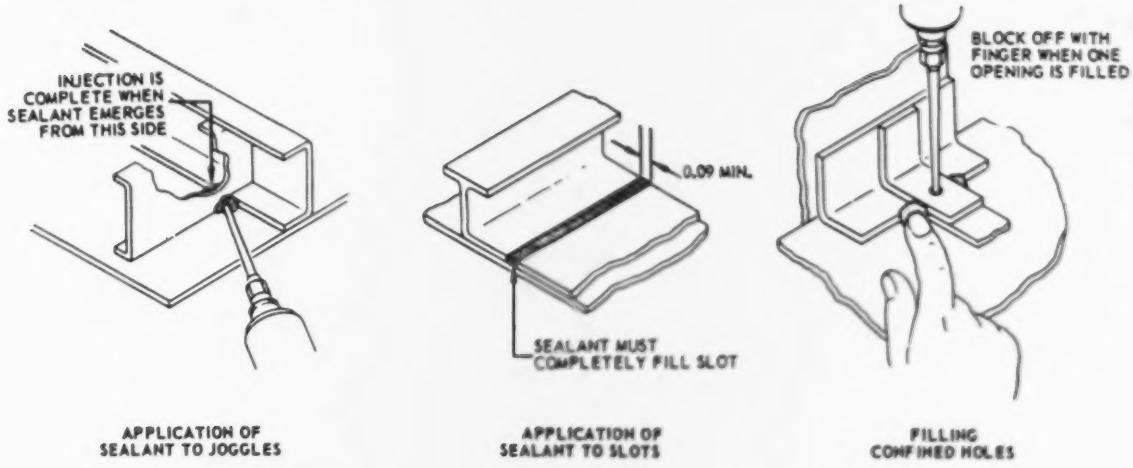

INJECTION IS COMPLETE WHEN SEALANT EMERGES FROM THIS SIDE
APPLICATION OF SEALANT TO JOGGLES
0.09 MIN.
SEALANT MUST COMPLETELY FILL SLOT
APPLICATION OF SEALANT TO SLOTS
BLOCK OFF WITH FINGER WHEN ONE OPENING IS FILLED
FILLING CONFINED HOLES

Figure 5-19. Application of sealant to joggles, slots and confined holes.

• Distilled or deionized water. This may be added during mixing in proportions not to exceed 3 percent by weight of the base compound.

• Aqueous solution of sodium bicarbonate, Specification O-S-576. This is saturated at 25° (+ 5° F.) in proportions not to exceed 3 percent by weight of the base compound.

When ambient temperatures are above 21° centigrade (70° F.) and the relative humidity is above 60 percent, it is not necessary to use additives to accelerate curing time.

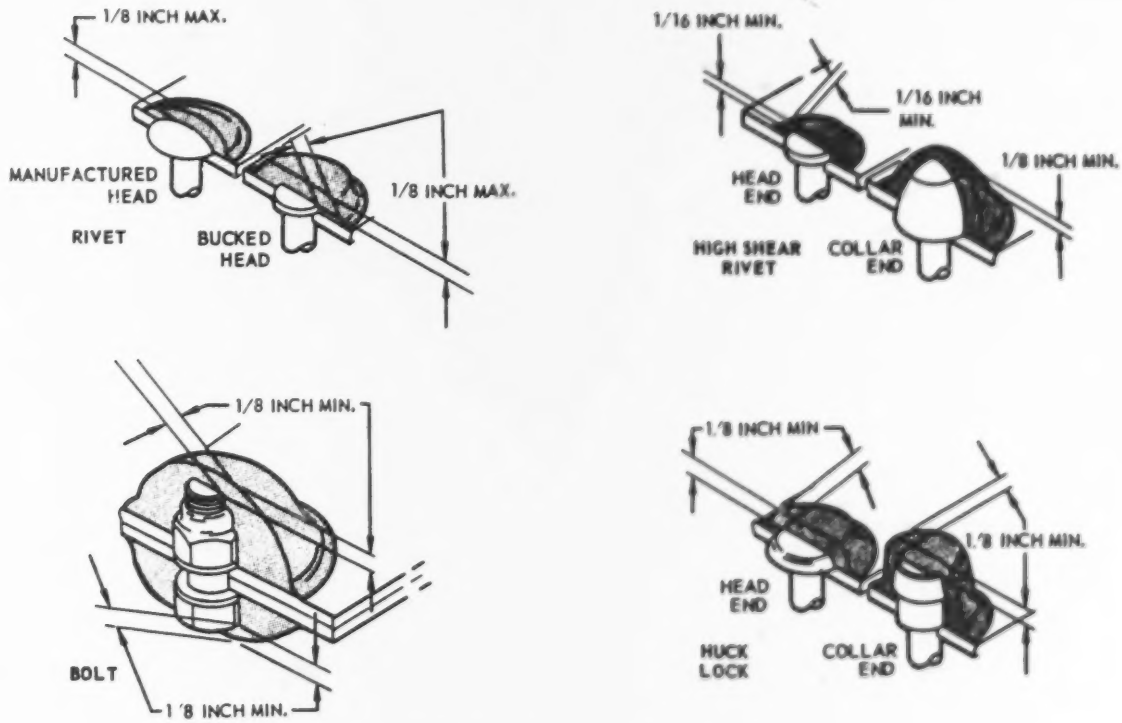
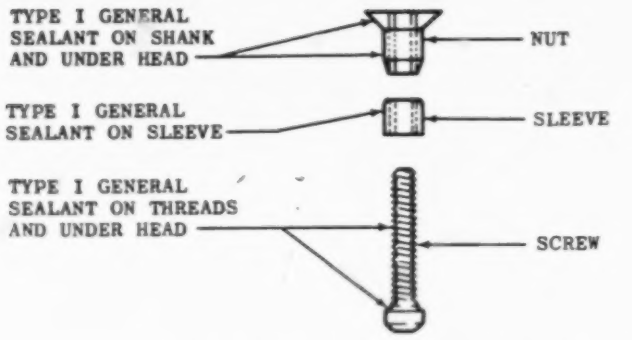


Figure 5-20. Typical methods of sealing fasteners.


TYPE I GENERAL SEALANT ON SHANK AND UNDER HEAD
NUT
TYPE I GENERAL SEALANT ON SLEEVE
SLEEVE
TYPE I GENERAL SEALANT ON THREADS AND UNDER HEAD
SCREW

DISASSEMBLED FOR SEALANT APPLICATION

INSTALLED

Figure 5-21. Blind fastener installation in fuel area.

Exercises (453):

1. What factors influence the time required to cure sealants?
2. What effect do low temperatures and low humidities have on the cure rate of sealants?
3. What is the ideal percentage of humidity recommended for curing sealants?
4. In which areas of an aircraft should you *not* use sealant that contains isopropyl alcohol?
5. What is the percentage of distilled or deionized water that may be added to a sealant to accelerate the curing time?
6. How may heat be applied to sealant to accelerate the curing time?
7. When applying heat to cure a sealant, what temperature must *not* be exceeded?

454. State selected safety precautions to follow when handling materials associated with structural sealing.

General safety precautions you need to observe are outlined in the following paragraphs. They are included here because they contain rules for handling materials with hazardous physical properties as well as emergency procedures for the immediate treatment of personnel who have inadvertently come into contact with one of the harmful materials. It is imperative that you be thoroughly familiar with this information.

General Safety Precautions. When you are required to use or handle any of the solvents, special cleaners, paint strippers (strong alkalies and acids), etchants (corrosion removers containing acids), or surface

activation material (Alodine 1200), observe the following safety precautions:

a. Avoid prolonged breathing of all solvents or acid vapors. To this end, solvents and acids must not be used in confined spaces without adequate ventilation or approved respiratory protection.

b. Never add water to acid, instead always add acid to water.

c. Do not mix chemical, except as prescried by applicable procedure.

d. Locate the nearest water supply before starting to work.

e. Avoid prolonged or repeated contact between skin and solvents, cleaners, etchants (acid), or conversion-coating material (alodine solution). To this end, wear rubber or plastic gloves when using such solvents, cleaners, paint strippers, etchants, or conversion-coating materials. Likewise, put on goggles or plastic face shields and rubber raincoats and rainhats when cleaning, stripping, etching, or conversion-coating overhead surfaces.

f. When mixing alkalies with water or other substance, use containers which are made to withstand heat generated by this process.

g. Wash any paint stripper, etchant, or conversion-coating material *immediately* from any body skin or clothing it may have contacted.

h. Promptly flush out with water all materials splashed into the eyes and send the injured person to the medical officer for further treatment.

i. Do not eat foods in or keep them in areas where they may absorb poisons. To this end, always wash your hands before eating or smoking.

j. When making a new tank of caustic or corrosive material, wear a mask and hood with an oxygen or air supply, rubber gloves, and a protective suit.

k. Always clean all equipment after completing work requiring it be used.

Exercises (454):

1. What is the safety rule for you to observe when you are working with acids?

2. When mixing alkalies with water or other substances, what factor must you remember?

3. What should you do if you have material splashed into your eyes?

4. State the safety precaution you should observe concerning all foods.

5. What is the recommended safety rule for you to follow when you are mixing chemicals?

Bibliography

Department of the Air Force Publications

TO 1-1A-1, *General Manual for Structure Repair.*
TO 1-1A-8, *Structural Hardware.*
TO 1-1A-9, *Aerospace Metals—General Data and Usage Factors.*
TO 1-1-3, *Preparation, Inspection, and Repair of Aircraft Fuels, Oil, and Water Alcohol Cells and Integral Tanks.*

TO 1-1-3, *Preparation, Inspection, and Repair of Aircraft Fuels, Oil, and Water Alcohol Cells and Integral Tanks.*

NOTE: None of the items listed in the bibliography above are available through ECI. If you cannot borrow them from local sources, such as your base library or local library, you may request one item at a time on a loan basis from the AU Library, Maxwell AFB AL 36112, ATTN: ECI Bibliographic Assistant. However, the AU Library generally lends only *books* and a limited number of *AFMs*. TOs, classified publications, and other types of publications are *not* available. Refer to current indexes for the latest revisions of and changes to the official publication listed in the bibliography.

560

Answers for Exercises

CHAPTER 1

Reference:

400 - 1. Drilling only one or two holes and when a power unit for a pneumatic (air) drill is not available.
400 - 2. Because most of the work an airframe repairman will do is located around flammable materials.
400 - 3. For drilling holes when a high degree of accuracy is required.
400 - 4. When the V-belts will deflect approximately 1/2 inch.
400 - 5. Goggles.

401 - 1. Overheating the twist drill.
401 - 2. Because the metal may crack.
401 - 3. No. The higher the twist drill number, the smaller the diameter of the twist drill.
401 - 4. The lips.
401 - 5. They allow the chips to escape, plus also allow the lubricant to flow easily down to the lips.
401 - 6. The web.
401 - 7. To smooth and enlarge holes to exact size.
401 - 8. They are very brittle.
401 - 9. Because they are used to complete the reaming of blind holes.
401 - 10. Expansion type reamers.

402 - 1. To sharpen the other cutting ip.
402 - 2. As many times as needed to obtain a perfect point.
402 - 3. This depends on the person grinding the twist drill.
402 - 4. By grinding the web on a thin, round, or beveled edge grinding wheel.
402 - 5. Cutting edges — check to see if both are the same length and desired angle.

403 - 1. Center punch indentation not deep enough.
403 - 2. After the hole is completely drilled.
403 - 3. 90° from the working surface.
403 - 4. Either the drill was off center when drilling or the drill was tilted when it was withdrawing from the hole.
403 - 5. A countersink or a larger twist drill than the hole.
403 - 6. Predrilling is drilling holes first slightly undersize, then to the original size.
403 - 7. 1/8.
403 - 8. No. Rivet holes must have a clearance of 0.002 to 0.004 thousandths.
403 - 9. Use Clecos.
403 - 10. For quick identification of different diameter sizes.

404 - 1. The angles in the countersunk rivets and diameter of the hole to be countersunk.
404 - 2. 0.001.
404 - 3. Countersink only material that is twice as thick as the countersunk portion of the rivet being installed.
404 - 4. Any four of the following will be correct:
Tipping the countersink to one side, oversized rivet holes, undersized countersink pilots, improper use of the countersink, a countersink in poor condition, countersink not running true in the chuck of the drill and lack of backside guide for the pilot on the countersink.
404 - 5. The thickness of the material.

405 - 1. To allow for springback.
405 - 2. When a countersunk rivet is used as the male dimpling die and a regular female die is used together to form dimpled holes.
405 - 3. Use the original rivet used to dimple the hole.
405 - 4. After the dimpling is completed.
405 - 5. The construction of the female die.
405 - 6. Facilitates removal of the metal after the dimple has been made.
405 - 7. The male die will enlarge and ruin the coining ram.
405 - 8. Because of possible hard spots in the metal.
405 - 9. Because the heating range of the machine is not high enough to effect dimpling.
405 - 10. Dimple the material when the thickness of the material is thinner than the thickness of the rivet head. For thicker material countersink the holes.

406 - 1. Nonstructural.
406 - 2. Diameter, length, and angle of countersink.
406 - 3. When high strength is required.
406 - 4. The head of the shear head countersunk rivet is smaller in diameter and thinner than the standard countersunk rivet.
406 - 5. Monel.
406 - 6. One-to-one.
406 - 7. More rivets are required in the area.
406 - 8. Only when the required countersunk rivet is not available and it is accomplished by driving the universal head from the opposite side and upsetting the shank in the countersunk recess (nest).
406 - 9. The hole of the standard countersunk rivet would be too large for the material.
406 - 10. A standard countersunk rivet of the same diameter as the shear head rivet, the head of the standard rivet is microshaved to proper smoothness.

407 - 1. Head markings.
407 - 2. a. B.
b. D.
c. AD.
d. DD.
e. M.
407 - 3. a. Military Standard.
b. Head style.
c. Material code.
d. Diameter in one thirty-seconds of an inch - (1/8).
e. Length in one-sixteenth of an inch - (5/8).
407 - 4. TO 1 1A 8, *Structural Hardware.*
407 - 5. Material composition of the rivets in the boxes.

408 - 1. Material composition of the rivet.

408 - 2. The type of heating equipment used.
408 - 3. 24 hours.
408 - 4. 20 minutes.
408 - 5. To delay the age hardening process as a result of the heat-treatment.

409 - 1. A 1/8 universal rivet set.
409 - 2. Flat.
409 - 3. 6 lbs.
409 - 4. 5/32.
409 - 5. 2.
409 - 6. 0.008.
409 - 7. 1 inch.

410 - 1. Allowing the bucking bar to vibrate in unison with the gun set.
410 - 2. 2 to 3 lbs.
410 - 3. Driving the shank end of the end of the rivet with a handset and a hammer and bucking the manufactured head with a handset held in a vise or a bottle bar.
410 - 4. When the rivet gun stops hammering.
410 - 5. ½ diameter high, 1½ diameter in width.
410 - 6. Placing shims under the end sets of both jaws.
410 - 7. The rivet's diameter.
410 - 8. Excessive hammering.
410 - 9. To temporary correct an unsatisfactory cupped condition on a rivet set.
410 - 10. The material may have become bulged towards the shop head.

411 - 1. Shear, bearing, and head.
411 - 2. When rivets are excessively strong in shear.
411 - 3. Tension.
411 - 4. They become overloaded.
411 - 5. Head failure.

412 - 1. Checking the formed shop head for proper dimensions.
412 - 2. Check to see if the rivet is flush with the surface.
412 - 3. Shifted or loose rivets.
412 - 4. Inspection of the rivet shank.
412 - 5. So that the hole will retain its original size and shape.
412 - 6. It is more symmetrical and there is less chance of damaging the rivet hole or the material around it.
412 - 7. One size smaller than the rivet diameter.
412 - 8. One-half the thickness of the top sheet.
412 - 9. Provide some type of backside support.
412 - 10. Because of the dimple in the head.

CHAPTER 2

413 - 1. Misalignment, cracks, and broken or missing tangs.
413 - 2. Deformation of bolt and elongation of the hole.
413 - 3. Fluorescent penetrant inspection should be performed.
413 - 4. Metallic ring test.
413 - 5. Pockets and corners where moisture may accumulate.

414 - 1. Patching.
414 - 2. Neligible.
414 - 3. Insertion.
414 - 4. Replacement.

415 - 1. Temporary.
415 - 2. One-time flight.
415 - 3. Permanent.
414 - 4. Combat repair.

416 - 1. Title page.
416 - 2. "A" page.
416 - 3. List of illustrations.
416 - 4. Section 1.
416 - 5. At the beginning of the particular section.

417 - 1. Make sure your using the correct TO.
417 - 2. The sections within the TO.
417 - 3. If specific illustration is given, then your research procedures are simple, but if a repair illustration isn't given, then further research is necessary.
417 - 4. Check the table of contents, looking for a breakdown index of the section so tha tyou can pinpoint the area within the section containing the damaged section.
417 - 5. Because additional research procedures may be required.

418 - 1. WL 302.
418 - 2. STA 130.
418 - 3. 6.60.
418 - 4. NAC. WL 100.
418 - 5. Rivets.
418 - 6. 3/16.
418 - 7. Universal.
418 - 8. 2017 T3.
418 - 9. 090 Clad 7075 T6.
418 - 10. BAC 1506 993.

419 - 1. TO 1-1A-1.
419 - 2. TO 1-1A-8.
419 - 3. TO 1-1A-9.
419 - 4. TO 1-1A-12.
419 - 5. TO 1-1A-8.

420 - 1. Maintaining original weight, contour, and weight.
420 - 2. The patch plate must have a cross-sectional area equal to, or greater than, that of the original damaged section.
420 - 3. Use material of a heavier gage to give equivalent cross-sectional strength.
420 - 4. By using what the manufacturer used is one way. The other way is to multiply the thickness of the skin by 3 and use the nearest larger sized rivet corresponding to that figure.
420 - 5. Length of the break, thickness of the material, shear strength, and bearing strength.
420 - 6. Reduction.
420 - 7. Control surfaces.

421 - 1. Aerodynamic smoothness.
421 - 2. If the damaged area is near or over a substructural member.
421 - 3. As reinforcement.
421 - 4. When the function of the part or the function of the part closeby requires a flush surface.
421 - 5. A combination repair is when both an exterior and an interior part are damaged in the same area.

422 - 1. Without a clear-cut definition of the problem, you and your worker may not be striving for the correct solution.
422 - 2. Fellow workers and supervisors can be consulted.

CHAPTER 3

423 - 1. Location of existing fasteners and allowance for the fastener spacing required in the filler and doublers.
423 - 2. Areas where a substructural member is not near the cut-out area.
423 - 3. Corner radii.

423 - 4. So that after removing the cutout material, existing rivets will be in proper edge distance to the edges of the cutout.
423 - 5. Where needed spaces is required for proper spacing of fasteners in the repair parts.

424 - 1. Thickness of the material, location of the damage, and equipment located behind the damaged area.
424 - 2. Material composition and thickness.
424 - 3. By drilling a number of holes large enough for insertion of long nose pliers into the cutout area. After the pliers are inserted, the metal is worked back and forth until it separates from the material.
424 - 4. Because only the skin knife should be used to make straight line cuts.
424 - 5. A rotary file should be used to remove the roughened edges and then a hand file or sandpaper is used to smooth the edges to the final dimensions required.
424 - 6. That the skin knife can cut you as easily as it cuts metal.
424 - 7. Pressure applied during the cutting strokes.

425 - 1. By insertion of a scrap piece of metal between the substructural member and the skin.
425 - 2. After final filing is completed.
425 - 3. Drill very carefully down into the skin and stop immediately just as the twist drill starts to break through the backside of the skin.
425 - 4. During filing operations.
425 - 5. By regulating the cutting pressure.

426 - 1. Not to damage surrounding equipment.
426 - 2. Reciprocating saw or hacksaw.
426 - 3. So the replacement part will fit properly.
426 - 5. Insert a scrap piece of metal between the substructural member and the skin.
426 - 6. Because of the limited space or location of the damaged substructural member.
426 - 7. It may be necessary to refer to them for repair information in later repair steps.

427 - 1. Edge distance, rivet patch, and transverse pitch.
427 - 2. Rivet diameter.
427 - 3. The edges are likely to turn up.
427 - 4. 2 rivet diameters.
427 - 5. Rivet pitch.
427 - 6. 6 to 8 rivet diameters.
427 - 7. 4 to 7 rivet diameters.

428 - 1. The shape of the cutout and location of the cutout.
428 - 2. Center point of the cutout area.
428 - 3. Pencil compass.
428 - 4. To keep from elongating fastener holes, prior to installation or countersinking.
428 - 5. They locate starting points for laying out the rivet location on the rows.
428 - 6. Outer rows first and after the filler plate is lubricated, the inner rows on the filler plate.
428 - 7. By using the measurements for rivet and transverse pitch.
428 - 8. The size of the cutout area and guidelines stated in the -3 technical order.
428 - 9. A pencil.
428 - 10. Because of the accuracy that can be accomplished by using them.

429 - 1. No, the first rivets on each side of the cutout area should be the edge distance required.
429 - 2. The width of the substructural member against the skin.
429 - 3. Use the rivet pitch developed on one of the cutout sides opposite the width of the substructural member.
429 - 4. The width of the substructural member.

CHAPTER 4

430 - 1. To make sure that enough metal is positioned on each of the cutout for the fastener locations.
430 - 2. The pattern on the skin is used as a template.
430 - 3. Size and shape of the cutout area.
430 - 4. The material is positioned behind the cutout, then the outline of the cutout is scribed on the material.
430 - 5. Blind area.

431 - 1. -3 TO.
431 - 2. Whether the fastener layout is developed on the part being repaired or on the repair part.
431 - 3. Locating the fastener holes and centering the patch plate so that proper allowance is maintained on both sides of the cutout area.
431 - 4. Hole finder method.
431 - 5. Location of the cutout or damaged area.

432 - 1. Amount of damage and number of patches or minor repair already on the skin panel.
432 - 2. Using the old skin panel as a template.
432 - 3. "Back-drilling" is the drilling of repair parts through existing fastener locations.
432 - 4. They damage the fastener holes.

433 - 1. The process used by the manufacturer in fabricating the part—formed or extruded.
433 - 2. Bend radius and width of flanges.
433 - 3. Smaller.
433 - 4. By positioning the filler into the cutout area, and scribing a cut line between the two ends of the original stringer.
433 - 5. The existing fastener locations, edge distance requirements, and size of the cutout area.

434 - 1. The amount of damage to each member and location of existing fasteners.
434 - 2. To prevent the repair parts from shifting during the drilling operation.
434 - 3. Material composition, temper, thickness, and contour.
434 - 4. 8 inches.
434 - 5. The thickness of the skin area.

435 - 1. The ability to hold a good scribing edge.
435 - 2. To allow for the material thickness of the filler plate.
435 - 3. Rectangular.
435 - 4. thickness.

436 - 1. Just prior to fastener installation.
436 - 2. When a repair part is placed over countersunk or dimpled holes and the repair part cannot be dimpled.
436 - 3. When a dimpled repair part is placed over original holes which were not countersunk or dimpled.
436 - 4. Zinc chromate primer.
436 - 5. Having to remove previously installed repair parts and deforming rivet shop heads.
436 - 6. The combined thickness of the material being riveted together.
436 - 7. 1½ times the diameter of the rivets being used.
436 - 8. To keep the repair parts from moving during the riveting process.

437 - 1. Reduces the areas where corrosion might start.
437 - 2. To insure proper curing of the compound.
437 - 3. Evaporative type (one-part) and the two-part type consisting of a filler and accelerator.
437 - 4. Compound surface hardness.

438 - 1. Strength, weight, contour, corrosion, and comparison to TO specifications.
438 - 2. Correct gage and composition of materials, size, type and installation of fasteners, heat-treatment requirements, and cutout radius and fastener layout.
438 - 3. Reject the part.
438 - 4. Does the repair meet the specifications of scale, material composition, heat-treatment, and tolerance?
438 - 5. Poor workmanship.

CHAPTER 5

439 - 1. An electrical impulse of low voltage and high amperage is discharged between the electrodes. As a result, the metal becomes molten and fuses together at the point of contact.
439 - 2. The point of contact or sport fused together on the metal is called the nugget.
439 - 3. The type and thickness of the metal being spotwelded.
439 - 4. The outer surface of a good spotweld should be smooth, free of cracks, and pits.
439 - 5. Resistance welding is easier, cleaner, quieter, and quicker than standard fastening procedures.
439 - 6. One method is to check the edge of the sheets, inspecting for sheet separation. The other method is to use a tapping test.

440 - 1. A rivet is inserted into the nugget area of the spotwelded area.
440 - 2. Material composition of the spotwelded area and the diameter of the fastener required.
440 - 3. So that the countersinking limits of the sheets spotwelded will not be exceeded.
440 - 4. By countersinking.
440 - 5. The washer must be six times larger than the rivet diameter and one gage thicker than the top skin.
440 - 6. When two or more spotwelds fail at the same area of a spotwelded structure.

441 - 1. It is simply a part of the aircraft structure that has been built in such a manner that after the seams, structural fasteners, and access doors have been properly sealed it will hold fuel without leakage.
441 - 2. Within the wings.
441 - 3. Weldable aluminum alloys.
441 - 4. To reduce the areas where leaks could develop.
441 - 5. Front, center, and rear sections.

442 - 1. A solvent action occurs which removes material fats and oil from the skin leading to dermatitis.
442 - 2. Reduce the buildup of static electrical charges.
442 - 3. Just prior to entering the fuel tank.
442 - 4. Air-driven.
442 - 5. Explosion proof.
442 - 6. All connections must be outside the fuel system maintenance area.

443 - 1. Scratches, dents, cracks, and holes.
443 - 2. Neligible damage.
443 - 3. Cracks.
443 - 4. Holes.
443 - 5. Neligible, repairable by patching, repairable by insertion, and repairable by replacement.

441 - 1. The type of fastening method used for the repair parts.
444 - 2. Crack cutout and damage cutout.
444 - 3. They are V-grooved using a rotary file.
444 - 4. The thickness of the material cracked and the length of the crack.
444 - 5. They must be chamferred.
444 - 6. Access to the backside of the dented area.
444 - 7. So as not to work-harden the area which will lead to cracks.
444 - 8. Aerodynamic smoothing compound.
444 - 9. Only small dents.
444 - 10. Follow technical order guidelines.

445 - 1. It must match the original material in thickness, material composition, temper, and contour.
445 - 2. It must be one gage thicker than the original skin thickness.
445 - 3. A welded filler restore the original strength to an area.
445 - 4. It must be chamferred.
445 - 5. Conventional methods - rivets, bolts and nuts, etc.

446 - 1. Fit, sealant requirements, and fastener installation.
446 - 2. Because the shank portion of fasteners, other than rivets, will not swell and thus fill the hole.
446 - 3. Pilot drilling, stepdrilling, and reaming techniques.

447 - 1. a. Intermediate.
b. Intermediate.
c. Absolute.
d. Extensive.
e. Absolute.
447 - 2. Limited sealing.

448 - 1. a. 4.
b. 7.
c. 6.
d. 1.
e. 9.
f. 10.
g. 3.
448 - 2. TO 1-1-3.

449 - 1. Soapless bubble fluid.
449 - 2. By passing the free end of a stethoscope or similar listening device along the seams in the suspected leakage area.
449 - 3. Air bubbles will expand at high altitude resulting in a damaged seal.
449 - 4. 2024-T3 aluminum alloy.
449 - 5. Most plastics generate static electricity.
449 - 6. So that the fillet seal will overlap the remaining portion of the old fillet seals in those areas.
449 - 7. To separate the seslant from the structure.

450 - 1. Sealant will not adhere to a surface which is not completely clean.
450 - 2. Methlethylketone (MEK).
450 - 3. At the top, working downward.
450 - 4. The oil, dirt, etc., which is floated to top of the surface will redeposit on the surface, where it cannot be removed with a dry cloth.
450 - 5. Pour the solvent on to the cloth - never dip the cloth into the solvent container.

450 - 6. Until there is no discoloration on a clean drying cloth.
450 - 7. Because of the oil on your fingers.
450 - 8. Provide adequate ventilation.

451 - 1. To check all outdated sealants, prior to use or discarding.
451 - 2. 9 months.
451 - 3. 1/3 of the normal storage limits, at each test or retest.
451 - 4. 50° to 80°
451 - 5. 2 hours.
451 - 6. MEK.
451 - 7. This is a two-part sealant cartridge designed for easy mixing and proper application of sealant in small quantities.
451 - 8. Wax-free.
451 - 9. Reduces the worklife.
451 - 10. The container must be stamped indicating the date tested and date of the next test.

452 - 1. Faying seal.
452 - 2. Fillet seal.
452 - 3. Fillet seal.
452 - 4. Injection.
452 - 5. Pressure side.
452 - 6. After final torque has been applied.
452 - 7. It must be disassembled, the individual parts cleaned, and sealant applied.
452 - 8. A cloth-back tape is used to cover the sealant preventing damage and keeping foreign material off the sealed area.
452 - 9. The nozzle tip should be maintained at 45° angle from the work surface and the sealant must be applied preceding the travel of the sealant gun.
452 - 10. Wait until the sealant reaches the tack-free stage.

453 - 1. Worklife of the sealant, ambient temperature, and relative humidity.
453 - 2. They lengthen the cure time.
453 - 3. 60 percent.
453 - 4. Areas containing acrylic plastics.
435 - 5. 3 percent.
453 - 6. Hot-air blowers, by heat lamps, or by prewarning the structure being sealed.
453 - 7. 120° F.

454 - 1. Never add water to acid—always add acid to water.
454 - 2. Mix in a container that can withstand the heat generated by the mixing process.
454 - 3. Flush with water and seek medical treatment.
454 - 4. Do not eat or keep food in areas where it may absorb poisons.
454 - 5. Do not mix chemicals except as prescribed by procedures.

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53153 03 S01 7904

SUPPLEMENTARY MATERIAL

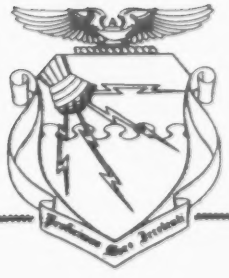
CDC 53153

AIRFRAME REPAIR SPECIALIST

(AFSC 42755)

Volume 3

IMPORTANT: Make the corrections indicated in this supplement before beginning study of this volume. This supplement contains both "pen-and-ink" changes and replacement pages. It is perforated and three-hole-punched so that you can tear out the replacement pages and insert them in your volume.



Extension Course Institute
Air University

CHANGES FOR THE TEXT: VOLUME 3

Pen-and-Ink Changes:

Page-Col	*Subject*	*Line(s)*	*Correction*
Cover			Change "AFSC 53153" to "AFSC 42755."
3R		3	Change "spondle" to "spindle."
9R		15	Change "hard" to "most."
9R		2 fr bot	Change "332" to "3/32."
9R & 10L		2 fr bot	Delete sentence "The size . . . its color."
11R		11	Insert "table 1-3" between "In" and "the."
13L		8	Change "your" to "you."
13L		14 fr bot	Change "advantage" to "disadvantage."
14R		8 fr bot	Change "Table 1-3" to "Figure 1-13."
18R		5	Change "1/6ths" to "1/16."
23L		2 fr bot	Delete "(not a 0.45)."
31L		9	Change "of" to "or."
37L		10 fr bot	After the word "manuals" insert the following: "-4 Illustrated Parts Breakdown technical orders."
63R		13 fr bot	Insert "skin knife" between "use" and "with."
65L		17	Change "step" to "stop."
68R		17 fr bot	Change "teh" to "the."
81L		22 fr bot	Change "shet" to "sheet."
81L		6 fr bot	Change "gold" to "old."
89R		25	Change "celcoe" to "celco."
95R		2	Change "derease" to "decrease."

Changes for Answers for Exercises:

125	402-1	1	Change "ip" to "lip."

Page Changes: Remove old pages and insert new pages as indicated. If the replacement pages number more than those they replace, those pages in excess of the pages being replaced will carry letter designations. For example: 20, 20a, 20b, etc.

Remove Pages	*Insert Pages*
49-50	49-50
109-110	109-110
125-126	125-126 a

aircraft, subsequent technical order, technical notes, or change orders, the latter should govern in all cases.

Aerospace Metals—General Data and Usage Factors, TO 1-1A-9. This manual contains concise information on metals to assist the services in selecting and preparing alternative metals for repair purposes. In all cases, of course, the services shall use the specified metals and the heat-treatment methods given in service specification and drawings when such materials and facilities for such treatments are obtainable.

Fabrication, Maintenance, and Repair of Transparent Plastics, TO 1-1A-12. This manual furnishes information related to transparent plastics. At present, this TO is only applicable to acrylics and modified acrylics. Information pertaining to polycarbondate-type plastics is contained in applicable -3 TOs.

Exercises (419):

1. General repair procedures are contained in which general engineering manual?

2. If you needed to identify a fastener head marking, which general engineering manual would you consult?

3. What general engineering manual outlines heat-treatment procedures for aircraft metals?

4. If you need information on how to repair acrylic plastics, which general engineering manual would you consult?

5. Working procedures related to tubing and flexible hoses can be found in which general engineering manual?

419a (Objective 455—for computer answer key and feedback reference only). Given examples of data found in a -4IPB TO, interpret their meanings.

Another valuable source of research information is the -4, *Illustrated Parts Breakdown,* technical order. It enables you to identify most procurable parts for a specific aircraft. Besides being able to help you identify parts, it can also help you save time, manpower, and materials. This technical order tells you:

- Whether a damaged part is procurable or designated local manufactured.
- Whether a damaged part is authorized to be repaired at your level of maintenance.
- Whether a damaged part can be condemned or processed out for depot level repair.
- In the case of missing fasteners, data such as how many are required, different diameters, specific grip lengths, and exact locations can be identified.

The -4, *Illustrated Parts Breakdown (IPB),* technical order usually consists of a number of volumes. For example, the B-52 aircraft -4IPB technical order consists of five volumes. Don't let the size or the number of volumes keep you from using the -4IPB because its research procedures are not that confusing. If you can locate repair information in a -3 TO, you can locate information in the -4IPB TO. The -4IPB TO sectional arrangement is simple in that only three sections are used. These sections consist of the Introduction, the Group Assembly Parts List, and the Numerical Index. Let's briefly take a look at these sections and see what information each provides.

NOTE: For purpose of our discussion, a Boeing Aircraft type -4IPB TO will be used. It will expose you to all characteristic features of most typical -4IPB TO arrangement in use today.

Section I, Introduction. This section is the "heart" of this TO in that it provides you with the "keys" to locating and interpreting the information contained in the other two sections. This section should be your first stop if you are unfamiliar with the -4IPB TO. Within this section you will find a short explanation of each individual section of the TO, different types of research procedurds, listings of SMR (source, maintenance, and recoverability) codes, related illustrated parts breakdown technical manuals, a listing of vendors codes, TCTOs incorporated, and lastly, a major assembly breakdown illustration of the entire aircraft.

Each of these areas is interrelated to each other in one way or another. Each will play an important part in the decision you will make based on the information you receive. The importance of each area will become clear as we discuss each one.

Introduction area. This area provides a brief insight into what is contained within each section. Additional information—such as which specific aircraft series and models this particular -4IPB TO covers, special ordering procedures related to parts kits, specific governing policies, and numbering designations unique to this -4IPB TO—is given.

SMR code listing. The SMR code is a six-digit position coding system. Each of the positions represents a specific factor. The first five positions are the ones that concern you. The last position, number six, is used by supply personnel to categorize replacement parts into various management groupings.

The following is a sequential listing of the positions used in an SMR code:

(1) The first two positions indicate the source for obtaining a replacement part. Figure 2-11A is a listing of the code letters and their definitions.

1. SOURCE CODES APPLICATION AND DEFINITION:

Source Codes are entered in the first and second positions of the Uniform SMR Code format as follows:

CODE	DEFINITION
PA	Item procured and stocked for anticipated or known usage.
PB	Item procured and stocked for insurance purposes because essentiality dictates that a minimum quantity be available in supply system.
PC	Item procured and stocked and which otherwise would be coded PA except that it is deteriorative in nature.
PD	Support item, excluding support equipment, procured for initial issue or outfitting and stocked only for subsequent or additional initial issues or outfittings. Not subject to automatic replenishment.
PE	Support equipment procured and stocked for initial issue or outfitting to specified maintenance repair activities.
PF	Support equipment which will not be stocked but which will be centrally procured on demand.
PG	Item procured and stocked to provide for sustained support for the life of the equipment. It is applied to an item peculiar to the equipment which because of probable discontinuance or shut down of production facilities would prove uneconomical to reproduce at a later time.
KD	An item of depot overhaul/repair kit and not purchased separately. A depot kit that provides items required at the time of depot overhaul or repair.
KF	An item of a maintenance kit and not purchased separately. A maintenance kit that provides an item can be replaced at organizational or intermediate levels of maintenance.
KB	Item included in both a depot overhaul/repair kit and a maintenance kit.
MO	Item to be manufactured or fabricated at organizational level.
MF	Item to be manufactured or fabricated at intermediate maintenance level. Air Force-Intermediate
MH	Item to be manufactured or fabricated at intermediate maintenance level. Air Force-Intermediate
MD	Item to be manufactured or fabricated at depot maintenance level.
AO	Item to be assembled at organizational level.
AF	Item to be assembled at intermediate maintenance level. Air Force-Intermediate
AH	Item to be assembled at intermediate maintenance level. Air Force-Intermediate
AD	Item to be assembled at depot maintenance level.
XA	Item is not procured or stocked because the requirements for the item will result in the replacement of the next higher assembly.
XB	Item is not procured or stocked. If not available through salvage, requisition.
XC	Installation drawing, diagram, instruction sheet, field service drawing that is identified by manufacturers' part number or obsolete.

Figure 2-11A. Source codes (first and second positions).

(2) The third and fourth positions represent the levels of maintenance authorized to use and repair a part. The third position indicates the lowest maintenance level authorized to remove, replace, and use the part. Figure 2-11B shows the code letters used and their definitions. The fourth position indicates whether a part is to be replaced and identifies the lowest maintenance level with the capability to repair the part. Figure 2-11C shows the code letters used and their definitions.

(3) The fifth position is the recoverability code. It is used to indicate the action taken when a part is declared unserviceable. Figure 2-11D shows the code letters used and their definitions.

Related illustrated parts breakdown technical manuals listing. This is a listing of additional technical orders which provide an internal breakdown of specific pieces of equipment. The listing is broken down into a

CODE	APPLICATION AND DEFINITION
O	Support item is removed, replaced and used at the organizational level of maintenance.
F	Support item is removed, replaced, use at the following intermediate levels: USAF - Intermediate
H	Support item is removed, replaced, used at the following intermediate level: USAF - Intermediate
D	Support items that are removed, replaced, used at depot only: USAF - Depot, Mobile Depot, and Technology Repair Center

Figure 2-11B. Maintenance code (third position).

CODE	APPLICATION AND DEFINITION
O	The lowest maintenance level capable of complete repair of the support item is the organizational level.
F	The lowest maintenance level capable of complete repair of the support item is the following intermediate level: USAF - Intermediate
H	The lowest maintenance level capable of complete repair of the support item is the following intermediate level: USAF - Intermediate
D	The lowest maintenance level capable of complete repair of the support item at the depot level: USAF - Depot, Mobile Depot, and Technology Repair Center
L	Repair restricted to designated Technology Repair Center.
Z	Nonrepairable. No repair is authorized.
B	No repair is authorized. The item may be reconditioned by adjusting, lubricating, etc., at the user level. No parts or special tools are procured for returning this item to a serviceable condition.

Figure 2-11C. Maintenance code (fourth position).

three-column format consisting of a parts number listing in an alphanumerical sequence (letters coming before numbers), a parts nomenclature (description) column, and a technical order number column indicating the specific TO for a specific piece of equipment. Figure 2-11E is an example of a related IPB technical manual listing.

Vendor's code listing. This listing provides the names and addresses of the manufacturers of replacement parts. A FSCM (Federal Supply Code for Manufacturers) coding system consisting of five digits is assigned to each manufacturer. Figure 2-11F is an example of a vendor's code listing.

TCTO incorporated listing. This is a listing of all the TCTOs that have been incorporated in the current -4IPB. Figure 2-11G is an example of a TCTO listing.

Major assembly breakdown. This is an exploded view of the major sections of the aircraft. Each of the individual sections has an index number which can be cross-referenced to a figure number. This assembly breakdown provides you with a starting point when researching information when you only know the approximate location of a part. Figure 2-11H is an example of a major assembly breakdown.

Section II, Group Assembly Parts List. This section contains illustrations and correspondingly numbered parts lists of replaceable parts for the aircraft. The illustrations and parts lists for the basic aircraft are arranged in main groups corresponding to the major assembly breakdown. This is the section from which you will obtain most of the information needed to order a replacement part. At the end of this section is a functional system parts list which contain a breakdown of the installations and assemblies within a specific system. These breakdowns provide a means of pinpointing the exact locations of parts within a system; they also provide the needed part number for ordering purposes.

Figure 2-11I (sheets 1 and 2) are sample pages of group assemble parts list. Take a few minutes and read the information indicated by each of the numbered callouts.

Section III, Numerical Index. The last section, illustrated in figure 2-11J, is the numerical index. It is an alphbetically and numerically arranged listing of the part numbers included in Section II. The figure and index numbers are given for reference to Section II in which each part number appears. Parts which appear in Section II with no part numbers are listed in an alphabetical sequence by the identifying noun in the part number column. Also given are the source, maintenance, and recoverability codes and the number of the same parts used throughout the aircraft (quantity per article).

Exercises (419a):

Refer to the appropriate figures in this objective segment as necessary to answer the following questions.

1. What is meant when the first two letters of a SMR code are MF?

CODE	APPLICATION AND DEFINITION
Z	Non reparable item. When unserviceable, condemn and dispose at the level indicated by the code in position 3.
O	Reparable item. When uneconomically repairable, condemn and dispose at organizational level.
F	Reparable item. When uneconomically repairable condemn and dispose at the following intermediate level: USAF - Intermediate
H	Reparable item. When uneconomically repairable, condemn and dispose at the following intermediate level: USAF - Intermediate
D	Reparable item. When beyond lower level repair capability, return to depot. Condemnation and disposal not authorized below depot level.
L	Reparable item. Repair, condemnation, and disposal not authorized below/ Specialized Repair Activity Level.
A	Item requires special handling or condemnation procedures because of specific reasons (i.e., precious metal content, high dollar value, critical material, or hazardous material). Refer to appropriate manuals or directives for specific instructions.

Figure 2-11D. Recoverability code (fifth position).

PART NO.	NOMENCLATURE	TECHNICAL ORDER NO.
AAU19A	Counter Drum Pointer Servo Altimeter	5F3-3-15-4
AAU8A	Pressure Sensitive Altimeter	5F3-3-9-4
AA6-08	Hydraulic Pressure Relief Valve	9H8-2-62-3
AFB243-100	Ground Cooling Alternator Blower	35E11-7-3
AM2714ALT16	ECM Transmitter Set Amplifier	12P3-2ALT16-4
AM2720A-APN89A	Electronic Control Amplifier	12P5-2APN81-64
AM2720APN89A	Electronic Control Amplifier	12P5-2APN81-64
AM3063APN150	Electronic Altimeter Set Amplifier	12P5-2APN150-4
AM3063A-APN150	Electronic Altimeter Set Amplifier	12P5-2APN150-4
AM608ARA25	Directional Finder Amplifier	12R1-2ARA25-4
AM743APN81	Electronic Control Amplifier	12P5-2APN81-54
AM924APS54	Radar Receiving Set Video Amplifier	12P6-2APS54-4
AM946A-APN89A	Electronic Control Amplifier	12P5-2APN89-54
AN-A1 Type	Bomb Group Selector	11B39-2-2-3
AN3203V30	DC Voltmeter	5M1-4-3-24
AN5766-4	Magnetic Compass	5N3-2-1
AN5769-1B	Hydraulic Pressure Gage	5P2-2-2-13
AN5839-1	Individual Landing Gear Position Indicator	5P3-3-3-3
AN6240-1	Vent Type Filter	9H3-4-2-3
AN6245AB4	Thermal Relief Valve Assembly	9H8-2-50-1
AN6245B4	Thermal Relief Valve Assembly	9H8-2-50-1
AN6248-2	Hydraulic Hand Pump Assembly	9H4-4-5-15
AN6249-6	Cone Check Valve Assembly	9H8-6-14-3
AN6249-8	Cone Check Valve Assembly	9H8-6-19-3
AN6277-6	High Pressure Hydraulic Valve Assembly	9H8-5-10-4
AN6279-8CD	Relief Valve	9H8-2-20-4
AN6279-8CD	Relief Valve	9H8-2-78-3
AN6281-8-120	Hydraulic Fuse (Type 1)	9H8-16-3-4
AN6281-8-60	Hydraulic Fuse (Type 1)	9H8-16-3-4
AN6287-1	High Pressure Air Valve Assembly	9P5-6-2-3
AQU4A Type	Horizontal Situation Indicator	5F8-16-4-4
ARU2B-A Type	Attitude-Director Indicator	5F8-3-11-14
ARU2B-A Type	Attitude-Director Indicator	5F8-3-21-4
ARU2B-A Type	Attitude-Director Indicator	5F8-10-7-4
ARU2B-A Type	Attitude-Director Indicator	5F8-20-3-4
AS1101APN89A	Doppler Radar System Antenna	12P5-2APN81-24
AS1188APS104	Radar Set Antenna	11B3-2-11-4
AS521A-APN69	Radio Beacon Antenna	12P5-2APN69-4
AS578CARA25	Direction Finder Antenna	12R1-2ARA25-4
AS578DARA25	Direction Finder Antenna	12R1-2ARA25-4
AS680APS54	Radar Set Antenna	12P6-2APS54-4
AT256A-ARC	Radio Set Antenna	12R2-2ARC34-4
AT256ARC	Radio Set Antenna	12R2-2ARC34-4
AVR869	400CPS 3-Phase 115/200V Phase Sensing Relay	8R1-2-14-3
AV1A1123	Solenoid Shutoff Valve	6R9-10-22-3
AV1A1132	Solenoid Shutoff Valve	6J15-10-1-44
AV1A3506	Solenoid Shutoff Valve	6J15-10-1-44
AV16B1426	Motor Operated Gate Valve	6J15-10-79-43
AW1 7-8 30F	Hydraulic Pressure Gage	5P2-2-13
AW2-17A	Hydraulic Pressure Gage	5P2-2-32-3
AW2-17G	Hydraulic Pressure Gage	5P2-2-36-2
A1 Type	Machmeter Indicator	5F8-8-2-4
A1 Type	Machmeter Indicator	5F8-8-2-14
A1 Type	Machmeter Indicator	5F8-8-2-24
A1 Type	Machmeter Indicator	5F8-8-2-34
A1 Type	Phase Sequence Indicator	8C15-4-2-23
A13A Type	Mechanical Aircraft Clock (non-lighted)	5N11-2-4-3
A155-1	Air Conditioning Controller Assembly	15A8-3-6-3
A158-1	Cabin Temperature Control Regulator	15A1-2-22-3
A17-1	Windshield Temperature Control Amplifier	8A3-9-2-3
A17932	Micro Switch Assembly	8D1-18-3-4
A18-1A	Cabin Temperature Control System Regulator	15E3-2-10-4
A18-1B	Cabin Temperature Control System Regulator	15E3-2-10-4
A18-1C	Cabin Temperature Control System Regulator	15E3-2-10-4
A18122	Electric Windshield Wiper Cam	8D1-18-3-4
A19-1G	Temperature Control Regulator	15E3-2-9-4
A19-1H	Temperature Control Regulator	15E3-2-9-4
A19-1L	Temperature Control Regulator	15E3-2-9-4
A19-1M	Temperature Control Regulator	15E3-2-9-4

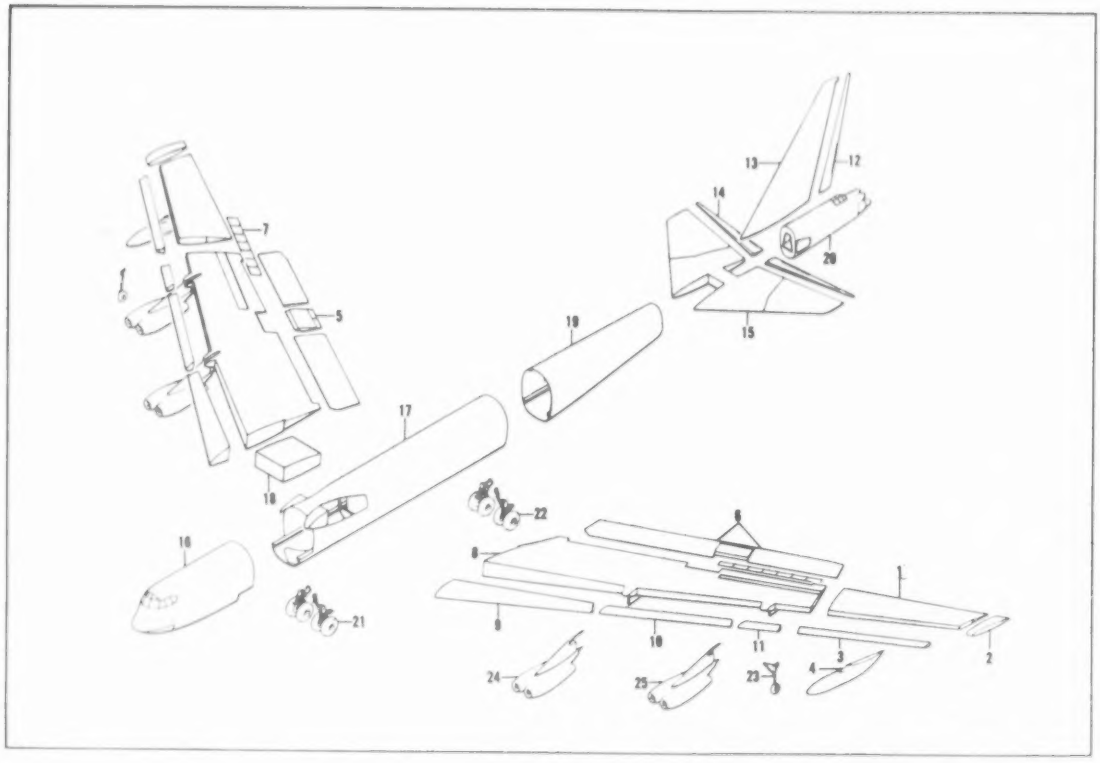
Figure 2-11E. Related IPB technical manuals.

FSCM	NAME AND ADDRESS
61349	Ametek Ill Gauge, Sellersville, Pa 18960
61483	Uniroyal, Inc, New York, N Y 10020
61864	United-Carr, Inc, Boston, Mass 02199
62793	Royal Industries, Inc, Engineered Products Div, Santa Ana, Calif 92705
64285	WEBCOR, Inc, Chicago, Ill 60614
64959	Western Electric Co, Inc, New York, N Y 10038
65035	Westinghouse Air Brake Co, Fluid Power Div, Lexington, Ky 40505
65054	Westinghouse Electric Corp, East Pittsburgh, Pa 15112
65092	Weston Instruments, Inc, Weston Instruments Div, Newark, N J 07114
65289	White-Rodgers Co, Afton, Mo 63123
65814	Williams, J. H., and Co, Buffalo, N Y 14207
66295	Wittek Mfg Co, Chicago, Ill 60623
70040	AC Spark Plug, Div of General Motors Corp, Flint, Mich 48556
70128	Aeroquip Corp, Aircraft Div, Western Plant, Burbank, Calif 91504
70138	Aero-Corry, Div of Aero-Flow Dynamics, Inc, Corry, Pa 16407
70152	Universal Oil Products Co, UOP Instruments Div, Greenwich, Conn 06830
70192	Gorn Corp, Stamford, Conn 06904
70195	Teledyne, Inc, Linair Engineering Div, Dania, Fla 33004
70203	Aircraft Mechanics, Inc, Colorado Springs, Colo 80907
70210	Airesearch Mfg Co, Los Angeles, Calif 90009
70309	(Refer to FSCM 02288)
70314*	Allied Research and Development Corp, New York, N Y
70417	Chrysler Corp, Amplex Div, Detroit, Mich 48211
70436	Arens Controls, Inc, Evanston, Ill 60202
70485	Atlantic India Rubber Works, Inc, Chicago, Ill 60607
70494	New Britain Div of Emhart Corp, New Britain, Conn 06050
70628	Arrowhead Products, Div of Federal-Mogul Corp, Los Alamitos, Calif 90720
70651	Atlas Brass Foundry, Inc, Los Angeles, Calif 90021
70843	Ball Bros, Inc, Muncie, Ind 47302
70898	Beech Aircraft Corp, Wichita, Kans 67201
70951	Electronic Communications, Inc, Benson Mfg Div, Kansas City, Mo 64127
71087	Boots Aircraft Nut Div, Townsend Co, Santa Ana, Calif 92707
71129	Bound Brook Bearing Corp of America, Bound Brook, N J 08805
71187	Brooks Equipment Corp, Hoboken, N J 07030
71225	(Refer to FSCM 09922)
71286	Camloc Div, Rex Chainbelt, Inc, Paramus, N J 07652
71294	Canfield, H.O., Co of Virginia, Inc, The, Clifton Forge, Va 24422
71400	Bussmann Mfg, Div of McGraw-Edison Co, St Louis, Mo 63107
71454	Chiksan Div, Petroleum Equipment Group, FMC Corp, Brea, Calif 92621
71468	ITT, Cannon Electric, Inc, Los Angeles, Calif 90031
71482	Clare, C. P., and Co, Chicago, Ill 60645
71503	Clary Corp, San Gabriel, Calif 91776
71607	Comar Electric Co, Chicago, Ill
71643	Connecticut Hard Rubber Co, New Haven, Conn 06509
71688	Cook Electric Co, Morton Grove, Ill 60053
71694	Corbin, P. and F., Div of Emhart Corp, New Britain, Conn 06050
71759*	Crystal Products Co, Kansas City, Mo
71785	Cinch Mfg Co and Howard B. Jones Div, Chicago, Ill 60624
71863	Kettering Aircraft Co, Inc, Dayton, Ohio 45404
71984	Dow Corning Corp, Midland, Mich 48641
72152	Electronic Resources Inc, Los Angeles, Calif 90039
72285	Exacto Industries, Inc, San Fernando, Calif 91340
72311	(Refer to FSCM 89446)
72314	Fairchild Camera and Instrument Corp, Defense Products Div, Syosset, Long Island, N Y 11791
72429	Sargent-Fletcher Co, El Monte, Calif 91731
72619	Dialight Corp, Brooklyn, N Y 11237

Figure 2-11F. Vendor's code listing.

TCTO NUMBER	ISSUE DATE
*1B-52-809	15 Mar 57
*1B-52-811	30 Aug 57
*1B-52-812	21 Feb 57
*1B-52-814	26 Jun 59
*1B-52-814A	31 Jul 59
*1B-52-815	30 Aug 57
*1B-52-816	1 Nov 57
*1B-52-817	" Mar 58
*1B-52-819	4 Oct 57
*1B-52-820	30 Aug 57
*1B-52-822	. 6 Apr 57
*1B-52-823	17 Jan 57
*1B-52-825	23 Aug 57
*1B-52-826	28 Mar 58
*1B-52-827	1 Mar 57
*1B-52-828	7 Feb 58
*1B-52-829	5 Apr 57
*1B-52-830	2 Jan 57
*1B-52-833	10 Dec 56
*1B-52-835	13 Aug 58
*1B-52-836	28 Jan 57
*1B-52-837	19 Aug 60
*1B-52-838	8 Mar 57
*1B-52-839	22 Aug 58
*1B-52-840	13 Dec 56
*1B-52-843	21 Feb 57
*1B-52-845	5 Feb 57
*1B-52-847	8 Nov 57
*1B-52-848	15 Mar 57
*1B-52-849	2 Aug 57
*1B-52-851	24 Jan 58
*1B-52-852	16 Aug 57
*1B-52-852A	30 Jan 59
*1B-52-854	15 Aug 58
*1B-52-855	27 Feb 57
*1B-52-855A	13 Sep 57
*1B-52-869	18 Feb 57
*1B-52-874	16 Jan 59
*1B-52-876	14 Oct 60
*1B-52-876A	17 May 61
*1B-52-877	28 May 57
*1B-52-877A	29 Oct 57
*1B-52-883	13 Aug 57
*1B-52-884	5 Apr 57
*1B-52-888	1 Nov 57
*1B-52-891	12 Mar 59
*1B-52-891A	1 Jul 62
*1B-52-892B	21 Aug 57
*1B-52-893	4 Oct 57
*1B-52-893A	17 Apr 58
*1B-52-897	12 Jun 57
*1B-52-897A	7 Jan 58
*1B-52-897B	22 Apr 58
*1B-52-898	17 Jan 58
*1B-52-903	11 Oct 57
*1B-52-903A	29 Nov 57
*1B-52-905	8 Nov 57
*1B-52-909	29 Apr 57
*1B-52-910	8 Aug 58
*1B-52-910A	23 Jan 59
*1B-52-912	22 Apr 57
*1B-52-915A	21 Aug 57
*1B-52-916	1 Nov 57
*1B-52-916B	16 Jan 59
*1B-52-917	18 Sep 57
*1B-52-917A	6 May 58
*1B-52-919	28 Jun 57
*1B-52-920	8 Nov 57
*1B-52-926	27 Jun 58
*1B-52-926A	13 May 60
*1B-52-928	26 Dec 58
*1B-52-932	26 Aug 57
*1B-52-936	14 Feb 58
*1B-52-936A	22 Apr 60
*1B-52-937	27 Feb 59
*1B-52-938	15 Aug 57
*1B-52-938A	10 Oct 57
*1B-52-938B	2 Jan 58
*1B-52-941	2 Feb 62
*1B-52-943	28 Mar 58
*1B-52-947	24 Dec 57
*1B-52-947A	21 Mar 58
*1B-52-949	18 Nov 57
*1B-52-951	4 Nov 57
*1B-52-951A	28 Apr 58
*1B-52-954	26 Dec 58
*1B-52-954A	27 Jan 61
*1B-52-955	22 Jan 60
*1B-52-955A	17 May 61
*1B-52-957	13 Nov 57
*1B-52-958	3 Feb 58
*1B-52-958A	1 Apr 59
*1B-52-958B	14 Oct 59
*1B-52-958C	15 Nov 60
*1B-52-959	24 Oct 58
*1B-52-959A	26 Mar 59
*1B-52-959B	27 Apr 59
*1B-52-959C	29 Jun 62
*1B-52-963	28 Jan 58
*1B-52-963A	27 Aug 59
*1B-52-963B	7 Oct 59
*1B-52-964	12 Dec 58
*1B-52-964A	20 Jul 62
*1B-52-967	23 Jan 58
*1B-52-969	13 Feb 58
*1B-52-971	29 Aug 58
*1B-52-971A	8 May 59
*1B-52-973	23 May 58
*1B-52-974	23 Dec 57
*1B-52-974A	21 Aug 59
*1B-52-976	29 Jan 58
*1B-52-977	30 Nov 59
*1B-52-977A	17 May 61
*1B-52-977B	22 Jun 62
*1B-52-979	28 Nov 57
*1B-52-979A	7 Feb 58
*1B-52-979B	28 Mar 58
*1B-52-982	20 Dec 57
*1B-52-984	30 May 58
*1B-52-984A	23 Jun 58
*1B-52-984B	23 Jan 59
*1B-52-985	5 Sep 58
*1B-52-985A	31 Oct 58
*1B-52-988	7 Mar 58
*1B-52-992	10 Oct 57
*1B-52-992A	3 Jan 58
*1B-52-995	21 Oct 59
*1B-52-997	30 Jan 58
*1B-52-999	14 Nov 58
*1B-52-1000	20 May 59
*1B-52-1000A	2 Nov 59
*1B-52-1003	12 Jun 59
*1B-52-1003A	17 May 61
*1B-52-1006	19 Feb 58
*1B-52-1007	6 Mar 58
*1B-52-1007A	6 Apr 59
*1B-52-1009	14 Apr 58
*1B-52-1009A	28 May 58
*1B-52-1011	15 May 58
*1B-52-1011A	2 Jan 59
*1B-52-1011B	5 Aug 60
*1B-52-1011C	15 Sep 60
*1B-52-1011D	17 May 61
*1B-52-1015	1 Apr 58
*1B-52-1018	28 Apr 58
*1B-52-1020	15 Aug 58
*1B-52-1020A	24 Oct 58
*1B-52-1025	14 May 58
*1B-52-1030	12 Dec 58
*1B-52-1031	9 Oct 59
*1B-52-1033	24 Oct 58
*1B-52-1033A	12 Jun 59
*1B-52-1034	19 Sep 58
*1B-52-1034A	21 Nov 58
*1B-52-1034B	23 Jan 59
*1B-52-1034C	16 Oct 59
*1B-52-1035	17 Oct 58
*1B-52-1035A	17 Dec 58
*1B-52-1038	25 Jul 58
*1B-52-1038A	7 Apr 59
*1B-52-1039	5 Aug 59
*1B-52-1040	16 Sep 60
*1B-52-1040A	13 Oct 60
*1B-52-1040B	17 Nov 61
*1B-52-1040C	20 Jul 62
*1B-52-1044	12 May 58
*1B-52-1046	2 Jun 58
*1B-52-1053	3 Jul 58
*1B-52-1054	25 Sep 58
*1B-52-1057	4 Dec 59
*1B-52-1057A	8 Apr 60
*1B-52-1059	28 Aug 58
*1B-52-1061	15 Sep 58
*1B-52-1061A	2 Feb 59
*1B-52-1062	27 Aug 58
*1B-52-1063	28 Aug 58
*1B-52-1067	30 Jan 59
*1B-52-1067A	17 May 61
1B-52-1070	14 Nov 58
*1B-52-1073	13 Feb 59
*1B-52-1073A	3 Apr 59
*1B-52-1073B	23 Sep 60
*1B-52-1073C	22 Jun 62
*1B-52-1074	24 Oct 58
*1B-52-1075	7 Oct 58
*1B-52-1076	10 Mar 60
*1B-52-1078	10 Oct 58
*1B-52-1079	29 Aug 58
*1B-52-1079A	24 Dec 58

Figure 2-11G. TCTO incorporated listing.



INDEX NO.			FIGURE NOS.
1	Section 21	Outboard Wing	2 thru 48
2	Section 29	Wing Tip	15
3	Section 22	Outboard Wing Leading Edge	13
4	Section 39	External Fuel Tank	49 and 50
5	Section 33	Aileron	51 thru 60
6	Section 36	Flap	61 thru 69
7	Section 31	Spoiler	70 thru 77
8	Section 11	Inboard Wing	78 thru 279
9	Section 13	Inboard Wing Leading Edge	120 thru 130
10	Section 14	Inboard Wing Leading Edge	131
11	Section 15	Inboard Wing Leading Edge	132 thru 134
12	Section 87	Rudder	280 thru 289
13	Section 85	Fin	290 thru 310
14	Section 82	Elevator	311 thru 318
15	Section 81	Stabilizer	319 thru 333
16	Section 41	Forward Compartment	334 thru 856
17	Section 43	Wheel and Bomb Bay Area	857 thru 1262
18	Section 12	Center Wing	859 thru 866
19	Section 47	Aft Equipment Compartment	1263 thru 1382
20	Section 49	Tail Compartment	1383 thru 1489
21	Section 61	Front Main Landing Gear	1490 thru 1499
22	Section 62	Rear Main Landing Gear	1490 thru 1499
23	Section 65	Tip Protection Gear	1500 thru 1503
24	Section 73	Inboard Power Plant	1504 thru 1591
25	Section 74	Outboard Power Plant	1504 thru 1591

Figure 2-11H. Major assembly breakdown.

1. Cross-reference by figure and index number indicates where the installation or assembly is listed under its next higher assembly.

2. "Ref" indicates the installation or assembly is listed again in the figure cross-referenced in the Description column (see note 1). The Units per Assembly is given in the referenced figure.

3. Military Specification Numbers are listed parenthetically in the Description column.

4. Optional parts are listed in parentheses in the Description column. Optional part numbers are listed in the numerical index.

5. Parts used in the quantity as required are indicated by "AR" in the Units per Assembly column.

6. Parts used only on left-hand or right-hand installations or assemblies may be designated by (LH only) and (RH only) or limited by a (used on . . . .) note in the description column. (see note 9)

7. Cross-reference by figure number indicates the figure in which the installation or assembly is broken down to its component parts.

8. Parts of other services, such as Signal Corps, are listed with the other services identifying number in parentheses in the Description column.

9. A (used on --) note in the Description column indicates the proper next higher assembly of a part when the part is not common to all of the next higher assemblies listed preceding the part.

10. A letter in the Usable on Code column corresponds to the code letter at the end of the parts list. Absence of a code letter in the Usable on Code column indicates usage of the part is not limited but is applicable to all AF serial number aircraft covered by the breakdown.

11. Boeing Specification Numbers are listed in the Description column.

12. Parts made by altering another part are indicated as (altered from --) in the Description column.

13. A number in the Units per Assembly column indicates the quantity of the part used per next higher assembly or installation.

14. GFAE appears in the Description column for all Government Furnished Aircraft Equipment.

15. Air Force handbook, sketch and experimental drawing numbers are shown in parentheses in the Description column.

16. Vendor codes for non military standards are in accordance with the Federal Supply Code for Manufacturers Cataloging Handbook H-4-1 and are shown in the Description column following nomenclature of the part. The absence of a vendor code, "GFAE", or a complete vendor name indicates the vendor to be The Boeing Company, Airplane Division, Wichita Branch, Wichita, Kansas (82918) except for BAC standards whose vendor is The Boeing Company, Seattle, Washington (81205). A list of all vendors' names and addresses is located in Section I.

17. The aircraft serial numbers corresponding to the code letters in the Usable on Code are given at the end of each coded parts list.

18. The symbol * is used to indicate aircraft serial number differences, due to modification, between this Illustrated Parts Breakdown and the production drawings. Parts with serialization differences have the part number preceded by the symbol *. The note pertaining to the symbol * is located at the end of the parts lists as necessary.

19. The symbol • is used to indicate parts added by modification. Parts added by modification have the part number preceded by the symbol •, thus indicating the part as one added by subsequent modification and not to be called for on the production drawing. The note pertaining to the symbol • is located at the end of the parts lists as necessary.

20. Boeing or vendor assemblies for which the Procuring Department has procured a separate Illustrated Parts Breakdown are identified by a note in the Description column. A list of these assembly parts numbers with their related Illustrated Parts Breakdown Technical Order numbers is included in Section I.

21. No entry in the Part Number column indicates the part has no applicable part number but is identified for procurement by the data in the description column including complete nomenclature, type number and specification number where applicable.

22. Air Force drawing numbers where applicable are shown in the Part Number column. These drawing numbers are identified by the code (USAF) in the Description column.

23. Vendors parts are identified by the vendors part number in the Part Number column and the vendor code following the nomenclature in the Description column.

24. Attaching parts are listed immediately following the part(s) attached. A symbol ---•--- follows the last item of the attaching parts.

25. No Number in the Part Number column is used to indicate the part is procurable from other services such as Ordnance, Signal Corps, etc. (See note 8.)

26. The number in the Figure and Index number column corresponds to the index number on the part in the corresponding illustration.

27. Boeing Standard Parts are identified by the BAC standard part number in the Part Number column.

28. The figure number refers to the corresponding illustration.

29. This is a typical Boeing part number. The digit preceding the first dash indicates the drawing size. The numerals immediately following the first dash constitute the remaining drawing identification. The numerals following the second dash identify a particular installation, assembly or detail part of that drawing.

30. A (for ref see fig. --) note in the description column indicates the figure where the adjoining installation or assembly is located.

31. A complete material description follows the nomenclature of parts that are within the facilities of any activity to manufacture.

32. A vendor number, for which a comparable Boeing Standard number has been assigned, will carry the Boeing Standard number in the description column for reference.

33. Letter codes in parenthesis, (a), (b), etc, denote parts used prior to or after an aircraft has complied with a Time Compliance Technical Order (TCTO). Usage of these coded parts is dependent upon aircraft records showing whether or not compliance with a TCTO has been accomplished. Coding explanations are located at the end of each figure. When an assembly or installation part number is coded the code applies to all the components.

34. Reference symbol (•) used for contractors reference use only.

Figure 2-111(1). Assembly parts list (sheet 1).

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2. What would the numbers 71984 after a description of a part indicate?

3. What is indicated by the absence of a Usable on Code?

4. What is meant if the third position in SMR code contains the letter D?

5. What SMR coding letter would be used to indicate that a part is repaired only at a Technology repair center?

6. What would be indicated if the last letter of an SMR code is coded A?

7. What would the numbers and letters ABC-S15Z-4 after a vendor's code indicate?

8. What is indicated by the SMR code of PAFZZ?

9. What would the symbol "#" indicate if found preceding a part number?

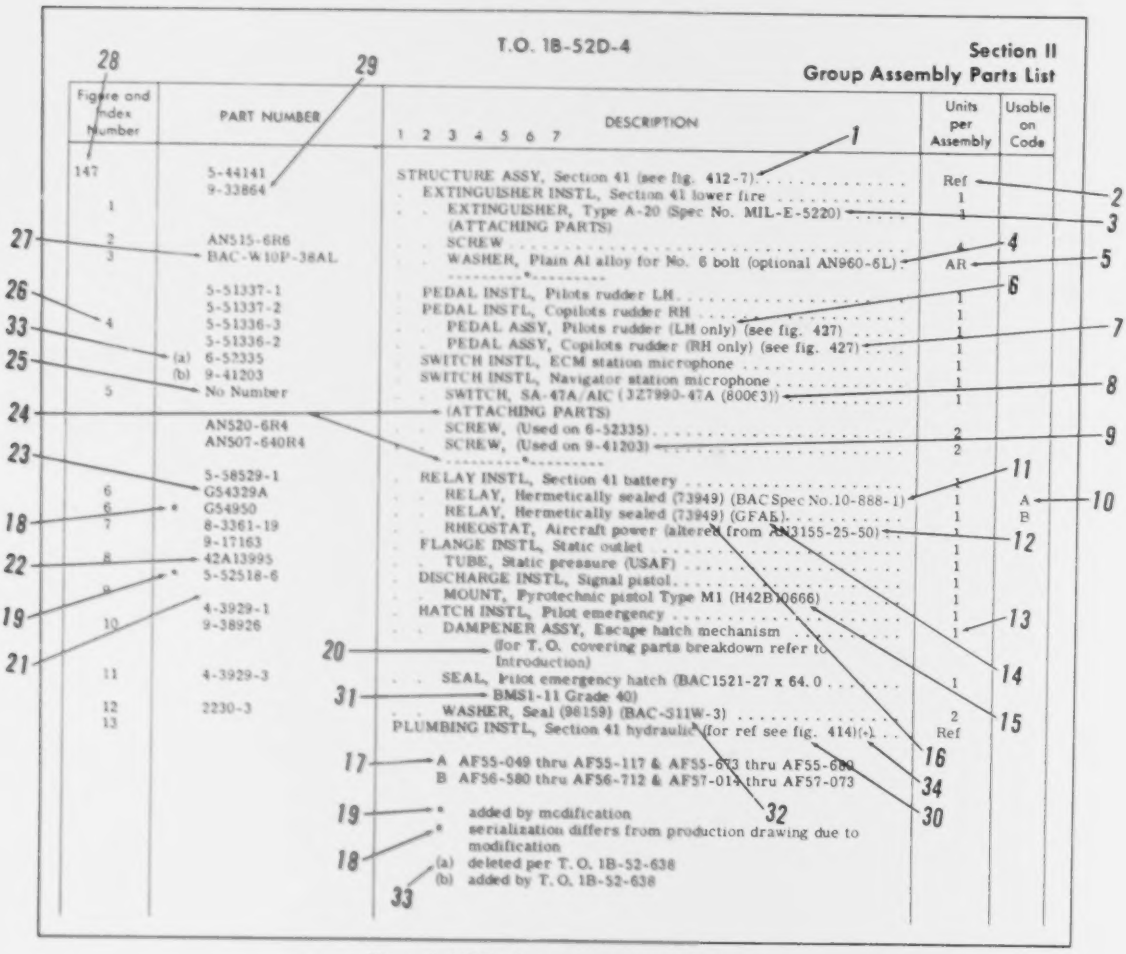

Figure 2-111(2). Assembly parts list (sheet 2).

PART NUMBER	FIG. AND INDEX NO.	QTY PER ART	SMR CODES
26-6265-1	82 - 45	2	XB----
26-6265-2	82 - 46	2	XB----
26-6267-3	82 - 55	2	XB----
26-6267-4	82 - 56	2	XB----
26-6276	827 - 26	8	XB----
26-6276-1	827 - 25	8	XB----
26-6283	792 - 27	1	XB----
26-6300	97 - 49	4	PA----
26-6322-501	97 - 34	4	PA----
26-6324	384 - 37	4	PA----
	387 - 36P		
26-6324-1	392 - 10M	2	PA----
26-6331-501	1588 -192	8	PA----
26-6338-501	62 - 27A	4	PA----
	64 - 42A		
26-6348-1	97 - 31	2	PA----
26-6348-2	97 - 32	2	PA----
26-6349	967 - 71	1	
26-6353-1	381 -	1	PA----
26-6353-2	381 -	1	PA----
26-6353-3	381 - 40	2	
26-6353-501	381 -	1	PA----
26-6353-502	381 -	1	PA----
26-6353-503	381 - 40A	1	XA----
26-6363	442 - 47B	2	
26-6365	1421 - 63A	2	PA----
26-6368	1421 - 3A	2	PA----
26-6369	1421 - 94A	2	PA----
26-6370	1421 - 96B	2	PA----
26-6370-1	1421 - 5B	2	PA----
26-6376	442 - 47A	2	
26-6386	967 - 69	1	XB----
26-6386-2	967 - 70	1	XB----
26-6386-3	967 - 64	2	XB----
	973 - 39		
26-6387	967 - 58	1	XB----
26-6387-1	973 - 33	1	XB----
26-6663	392 - 2A	4	PA----
26-6668	385 - 13J	6	PA----
	390 - 17P		
	394 - 17P		
26-6668-1	385 - 21A	6	PA----
	390 - 25A		
	394 - 25A		
26-6686	387 - 27A	2	
26-6694	1452 - 35	1	XB----
26-6696	994 - 6	2	XB-Z--
	994 - 8B		
26-6503	99 -	2	PA----
26-6503-1	99 - 52	2	XB----
26-6509	587 - 80	2	XA----
	587 - 80A		
26-6519	97 - 48	2	PA----
26-6521	1452 -	1	XB----
26-6521-1	1452 - 28	1	
26-6521-2	1452 - 32	1	
26-6553	308 - 9	2	
26-6554	1001 -	2	XB----
26-6555	1001 -	2	XB----
26-6556	1001 -	2	XB----
26-6559	510 - 50B	2	
26-6575	97 - 47	2	PA----
26-6578	734 -293	1	XB----
26-6586	1122 - 88C	1	XB----
26-6595-6	97 - 38	4	MF----
26-6610	959 - 51	1	PA----
26-6614	1511 - 21	4	PA----
26-6628	959 -145	1	PA----
26-6629-1	615 - 35	1	XB----
	615 - 87		
26-6629-2	615 - 36	1	XB----
	615 - 88		
26-6639	959 -105	1	PA----
26-6642	959 - 68	1	PA----
26-6666	587 - 83	1	XA----
26-6672-9	98 - 38	2	XB----
26-6682	490 -	1	
26-6683	98 - 18	2	PA----
26-6691-501	1255 - 17	1	PA----
	1256 - 21		
26-6692	959 - 97	1	XB----
26-6733	968 - 21	1	XB----
26-6736	553 - 4Z	1	XB----
26-6740	959 -139	1	XB----
26-6750	696 - 27	1	
26-6757-5	129 - 93	2	XB----
26-6766	1553 -	4	PA----
26-6767	1553 - 23G	4	
26-6773-5	968 - 30	1	XB----
26-6773-6	959 -103	1	XB----
26-6773-7	959 -104	1	XB----
26-6785	1587 - 28	4	PA----
26-6785-501	1587 - 28	4	PA-F--
26-6822	1520 - 37B	4	PA----
26-6834	1530 - 88	1	PA----
	1530 - 88B		
26-6836-504	99 - 16	8	PA----
	99 - 37		
26-6845	398 - 26	1	XB----
26-6847	398 - 24	1	XA----
26-6848	398 - 20	1	XA----
26-6855	1476 - 55	2	XA----
26-6877-1	137 - 86	1	XB----
26-6877-2	137 -	1	XB----
26-6878	959 - 80	1	PA----
26-6878-2	959 - 58	1	PA----
26-6886	137 - 79	2	PA----
26-6889	137 - 83	2	PA----
26-6915	386 - 25	8	XB----
	387 - 15D		
26-6915-1	386 - 24	8	XB----
	387 - 15B		
26-6916	386 -	8	PA----
	387 -		
26-6931-1	992 - 76	2	PA----
26-6931-2	992 - 77	2	XC----
26-6931-501	992 - 76	2	
26-6931-502	992 - 77	2	
26-6935	992 - 79	4	PA----
26-6935-501	992 - 79	4	
26-6936	992 - 78	4	MF----
26-6936-501	992 - 78	4	
26-6937	959 -120	1	PA----
26-6938	959 -123	1	PA----
26-6950-501	992 - 67	8	PAFZZ-
26-6951	359 - 33	1	XB----
26-6952-501	992 - 51	4	PA----
26-6955-1	992 - 49	4	PA----
26-6955-2	992 - 50	4	PA----
26-6959	386 - 32	2	XA----
26-6959-2	386 - 32	2	XA----
26-6974	546 - 50	1	XB----
26-6976	386 - 42	1	XB----
26-6977	386 - 45	1	XB----
26-6984	1611 - 38	1	XB----
26-6985	1611 - 38	1	XC----
26-6991	1611 - 38	1	XC----
26-6997	1490A- 17	16	PA----
26-7042-3	379 - 20G	1	PADFFP
26-7042-4	379 -	1	
26-7063	1452 - 12	1	XB----
26-7069	1452 - 11	1	XB----
26-7080	607 -	1	XB----
26-7080-1	607 - 38	1	XB----
26-7080-501	607 - 40	1	XB----
26-7083	969 - 14	1	XB----
26-7085	1452 - 10	1	XB----
26-7088	98 - 15	8	PA----
	98 - 34		
26-7089	98 - 21	2	PA----
	98 - 39		
26-7089-1	98 - 22	2	PA----
	98 - 40		
26-7090	971 - 7	1	PA----
26-7094	971 - 4	1	PA----
26-7160-1	971 - 21	1	XB----
26-7160-501	971 -	1	PA----
26-7170-501	971 - 25	1	XB----
26-7170-502	971 - 26	1	XB----
26-7170-503	971 - 27	1	XB----
26-7170-504	971 - 28	1	XB----
26-7228-1	1390 - 67	1	
26-7228-2	1390 - 68	1	
26-7231-501	1515 - 41	8	PA----
	1569 - 83		
	1571 - 83		
26-7247	582 - 31	1	XB----
26-7255-502	1514 - 20	8	
	1515 - 13		
26-7256-501	1514 - 25	8	
	1515 - 18		
26-7263-501	1514 - 26	8	
	1515 - 19		
26-7263-502	1514 - 27	4	
	1515 - 20		
26-7265-502	1514 - 28	8	
	1515 - 21		
26-7705-503	1512 - 14	8	PA----
26-7705-504	1512 - 18	8	PA----
26C02	490 -209	34	PA----
	568 - 24		
	633 - 26		
	635 - 13		
	727 - 6		
	1473 - 8		
26C048	400 - 50	7	PA----
	564 - 19		
26R1-1	273 - 30	15	PA----
	273 - 30B		
	1207 - 22		
	1207 - 50		
	1208 - 2		
26S8-17	335 - 52R	13	
26S8-3	335 -102	13	
26S8-5	771 - 64	3	PA----
	1208 - 5		
260-18-1	1191 - 7	2	PA----
2600-10	659 - 20	27	PA----
	1337 - 9		
2600-12W	659 - 21	8	PA----
2600-2	393 - 9	47	PA----
	713 - 23		
	787 - 15		
	850 - 3		
	850 - 18		
	855 - 3		
	1177 - 54		
	1217 - 1		
	1223 - 2		
	1224 - 3		
	1537 - 15		
2600-3	270 - 6	244	PA----
	273 - 4		
	273 - 4A		
	359 - 21		
	362 - 12		
	393 - 8		
	393 - 20		
	411 -		
	696 -		
	696 - 46		
	706 -		
	706 - 41		
	706 - 80		
	706 - 88		
	706 - 91		
	706 -117		
	727 - 15		
	740 - 30		
	765 - 30		
	767 - 41		
	772 - 25		
	773 - 9		
	775 - 12		
	776 - 3		
	777 - 2		
	778 - 17		
	779 - 16		
	779 - 17		
	781 - 3		
	783 - 35		
	783 - 39B		
	786 - 4		
	800 - 4		
	800 - 22		
	813 - 1		
	829 - 1		
	829 - 22		
	832 - 9		
	835 - 2		
	854 - 75		
	1178 - 85B		
	1183 - 1		
	1193 - 1		
	1202 - 1A		
	1203 - 1		
	1204 - 11		
	1205 - 8		
	1206 - 9		
	1215 - 3		
	1376 - 18		
	1378 - 19		
	1477 - 49		
	1480 - 7		
	1484 - 1		
2600-35W	706 - 81	2	PA----
	706 - 96		
2600-3W	367 - 11	53	PA-Z--
	706 -		
	706 - 77		

Figure 2-11J. Numerical index.

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10. What is indicated when a figure and index number given in the numerical index is not preceded by a part number?

419b (Objective 456—for computer answer key and feedback reference only). Indicate why a particular research step is needed when locating information in the –4IPB TO.

Now that you know what information is in the –4IPB TO, the next step is locating specific information. How you go about locating needed information will depend on what you know prior to opening a –4IPB TO. Facts such as whether you have a part-number, the part itself, or just the fact you know the location of the part on the aircraft, will determine the course of action you take to locate information in the –4IPB TO.

Research Procedures I—Part Number Is Not Known. Let's assume that you receive a work order to replace "missing fasteners" on the cover panel of the Special Weapon Emergency Release circuit breaker assembly in the wheel-well of a B–52 aircraft. At the aircraft you find that both cover panel fasteners are missing. Since this is the first time you have worked on this circuit breaker panel, you have no idea what type fasteners are used.

There are a number of ways you can solve this problem. First, you can go look at another aircraft; or to be really sure you use the correct type, length, and diameter fasteners, you should research the needed information in the –4IPB. The latter course is the way to go.

The "key" by which you can locate this information is the fact you know the name of the part being repaired, in this case—"Special Weapon Emergency Release circuit breaker panel." Also, you know the location of the circuit breaker panel on the aircraft. Both these facts will enable you to quickly zero in on the needed information in the –4IPB TO.

The following are the steps you should use:

(1) Turn to the major assembly breakdown illustration for the aircraft (Introduction Section). This is where knowing the location of the part being repaired comes into play. Figure 2-11H indicates that the damaged part is located within index number 17. This area is numbered Section 43 and is called the Wheel and Bomb Bay Area. The figures that covers this area run from 857 through 1,262 (see fig. 2-11H).

(2) Turn to the table of contents. The table of contents is broken down into sections the same as those shown in the major assembly breakdown. Once you have located the section that pertains to the Wheel and Bomb Bay Area, it's just a simple matter of going down through the parts descriptions until you find the one needed. This is where knowing the name of the part or unit being repaired comes into play. Figure 2-11K indicates that the "Special Weapons Emergency Release Circuit Breaker Kit" is shown in figure 1,208 on page 3,927.

(3) Turn to the figure given in the table of contents for the circuit breaker assembly. Figure 2-11L is an exploded view of the circuit breaker assembly. The area that you are concerned with is the cover panel. The index number that gives the information related to missing fasteners is numbered 5. The part number is 26S8-5, and the description is "Stud Assy, Quick Release Fastener (71286) (BACS21Y5R)." There are two fasenters in the cover panel, and the Usable on Code is "A." Armed with this information, you can insure that the correct type, length, and diameter fastener (studs) are used as replacements. Additional hardware needed along with the stud assy is shown in index numbered 6 and 7.

Research Procedures II, Part Number Is Not Known. This research procedure differs in the fact that the part being repaired is a component of a functional system. Examples of functional systems are the electrical system, the throttle control system, and drag chute control system.

Let's assume that you have patched a "hat-channel" support member for the life raft release control system. The patch you installed was over an attachment point (bolt hole) on the "hat-channel" position of the bracket assembly. What you need to know is how much longer should the replacement bolt be, since additional material was added to the attachment point. To solve this problem using the –4IPB TO follow these steps:

(1) Turn to the last sectional breakdown of the table of contents. This last sectional breakdown contains a listing of the different functional systems found throughout the aircraft. Since you are working on the life raft release system, simply find the figure number that gives a breakdown of this system.

(2) Turn to the numbered figures given in the table of contents. Figure 2-11M is an overall view of the entire life raft release control system. It is at this point that the location of the repaired area plays an important role. For our situation, let's assume the repair was made in the area of the index number 6. Index number 6 gives a part number, but is this what you need? You repaired only a support member, not the entire bracket assembly. What you need is a closer look at this bracket assembly. Within the description of the bracket assembly is a reference figure. The reference figure given is 977.

(3) Turn to the reference figure. Figure 2-11N is an exploded view of index number 6, given previously in the functional system figure 2011M. Since you repaired only the "hat-channel" support member of the bracket assembly, index number 5 is the item you need to study. The attachment bolts for index number 5 are called-out in index number 6. At this point, you know the original bolt length, and based on how thick the patch material was, you can select the correct length replacement bolt.

Figure 1194.	RH Aft AC Power Load Box Installation	3886
Figure 1195.	AC Power Load Junction Box Assembly	3891
Figure 1196.	Right Hand Aft AC Load Box Upper Equipment Panel Assembly	3892
Figure 1197.	Right Hand Aft AC Load Box Lower Equipment Panel Assembly and Installations	3898
Figure 1198.	Left Hand Aft AC Power Distribution Box Installation	3900
Figure 1199.	RH Aft AC Power Distribution Box Installation	3906
Figure 1200.	Rear Spar Wing Break Box Installations	3910
Figure 1201.	Right Hand Forward DC Junction Box Installation	3912
Figure 1202.	Right Hand Forward DC Junction Box Assembly	3917
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Figure 1206.	Battery Fuse and Circuit Breaker Shield Installation	3922
Figure 1207.	Station 538 Aft Battery Power Box Kit Installation	3925
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Figure 1209.	(Deleted)	
Figure 1210.	(Deleted)	
Figure 1211.	Aft AC Power Box Kit Installation	3938
Figure 1212. thru Figure 1214.	(Deleted)	
Figure 1215.	Station 1237 Auto-pilot Terminal LH Panel Installation	3955
Figure 1216.	Alternator Control Panel and Terminal Strip Installations	3956
Figure 1217.	Station 526 Front Spar Wing-Body Break Panel Installations	3959
Figure 1218.	AN-A1 Bomb Group Selector Installation	3960
Figure 1219.	AN-A1 Bomb Group Selector Installation	3960B
Figure 1220.	(Deleted)	
Figure 1221.	Bomb Salvo Time Delay Station 917 Relay Installation	3962
Figure 1222.	Bomb Bay SWESS Panel Equipment Kit Installation	3966
Figure 1223.	Station 725 to 745 LH Side Terminal Box Installation	3969
Figure 1224.	Station 735 to 745 RH Electrical Wiring Terminal Installation	3970
Figure 1225.	Station 505.8 LH Terminal Board Installation	3971
Figure 1226.	Stations 805 and 1237 Electrical Terminal Installations	3972
Figure 1227.	Body Station 1028 Electrical Terminal Installations	3974
Figure 1228.	Stations 715, 725 and 879.4 Interphone Terminals Disconnect Installations	3976
Figure 1229.	Station 917 LH Bomb Control Wiring Terminal Installation	3978
Figure 1230.	Landing Gear Electrical Wiring Terminal Installation	3979
Figure 1231.	Aft Alternator Equipment and Transformer Installations	3980
Figure 1232.	Engines 7 and 8 Thermocouple Resistor Installation	3983
Figure 1233.	Engines 1, 2, 3, 4, 5 and 6 Thermocouple Resistor Installations	3984
Figure 1234.	Bomb System Relay Box Kit Installation	3986
Figure 1235.	Forward Battery Rectifier Installation	3987
Figure 1236.	Hydraulic Pack No. 1, 2, 3 and 4 Timer Installations	3988
Figure 1237.	Station 435 Bulkhead Battery Installation	3994
Figure 1238.	Station 544.5 to 551 Battery Installation	3996
Figure 1239.	Armament Provisions Battery Kit Installation	3998
Figure 1240.	Forward and Aft Battery Vent Installations	4000
Figure 1241.	Walkway, Bomb Bay and Fuselage Top and Bottom Light Installations	4002
Figure 1242.	Station 1238 Lower Anti-collision Light Installation	4004
Figure 1243.	Center Section Wing Conduit Installation	4006
Figure 1244.	Center Section Wing Tank Conduit Installation	4008
Figure 1245.	Forward and Aft Main Landing Gear Trunnion Conduit Installations	4009
Figure 1246.	Forward Wheel Well Landing Lights Conduit Installations	4011
Figure 1247.	Fuel Level Control Body Electrical Conduit Installations	4012
Figure 1248.	Interphone and Fuel Quantity Electrical Conduit Installation	4014
Figure 1249.	Station 715 to 1237 Interphone Wiring Conduit Installations	4016
Figure 1250.	Station 795 to 1237 LH Side and Station 715 to 1046.4 RH Side Conduit Installations	4018
Figure 1251.	Section 43 Fuel Quantity A-3A Fire Control and Coaxial Cable Electrical Bundle Assemblies	4020
Figure 1252.	Section 43 Landing Gear Actuator and Control Bundle Assembly	4022
Figure 1253.	Forward Main Gear Conduit Box Assemblies	4025
Figure 1254.	Main Gear Actuator Shaft Transfer Switch Assembly	4026
Figure 1255.	Station 694 Bomb Safety Switch Installations	4027
Figure 1256.	Bomb Bay Lights and Station 1028 Bomb Safety Switch Installations	4030
Figure 1257.	Main and Interphone External Power Receptacle and Structure Installations	4032
Figure 1258.	Bomb Bay Receptacle Support Installations	4034
Figure 1259.	Fuel Nozzles Grounding Jack Installations	4036
Figure 1260.	Station 624.5 to 715 Wire Support Tray Installations	4037
Figure 1261.	Stations 540.5 to 587.5 and 485.7 to 555 Wire Support Tray Installations	4039
Figure 1262.	Station 588.5 to 623 LH Wire Support Tray Installation	4041

Figure 2-11K. -41PB TO, Table of Contents.

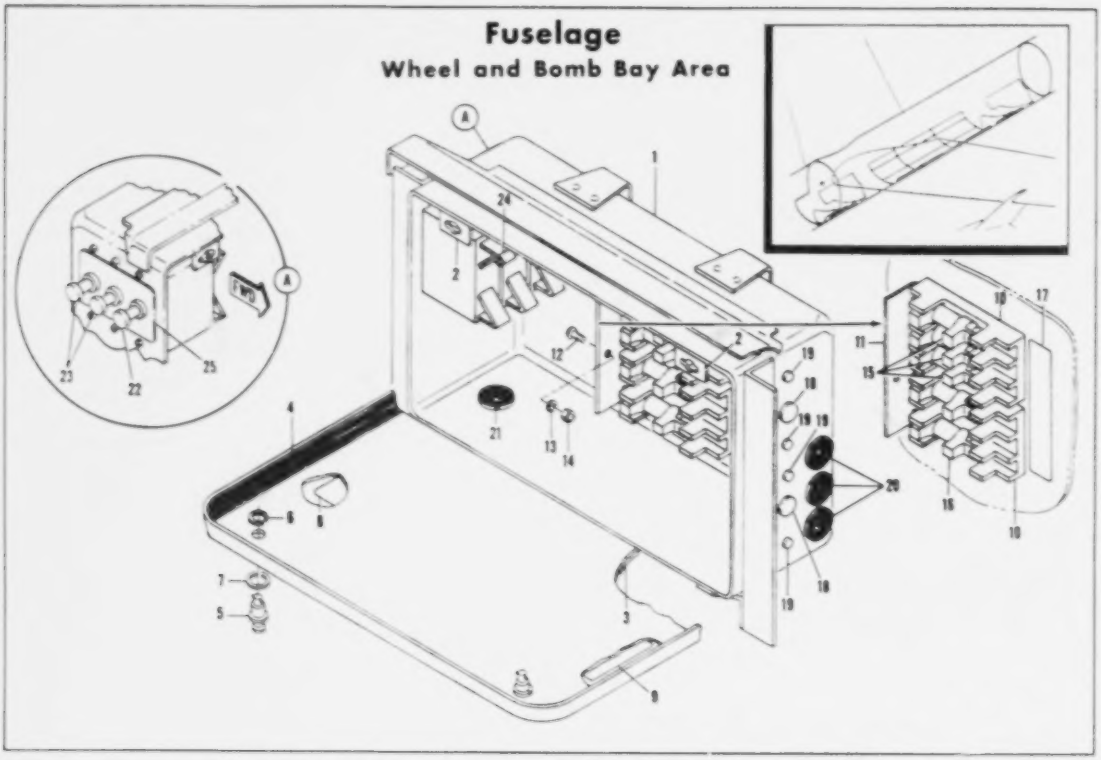

Figure 1208. Special Weapons Emergency Release Circuit Breaker Kit Installation

Figure and Index Number	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	Units per Assembly	Usable on Code
1208				
	(a) 35-29344-1	KIT INSTL, Special weapons emergency release circuit breaker (J-79)	1	A
	29-5979-515	. BOX ASSY, Aft battery power	1	A
		(ATTACHING PARTS)		
	NAS603-18P	. SCREW	4	A
	BACW10P42S	. WASHER, Plain steel	4	A
		-------*-------		
1	29-5979-516	. . BOX, Aft battery power	1	A
2	26R1-1	. . RECEPTACLE, Series 2600 quick release (71286) (BACR11Y4A)	2	A
	29-5979-518	. COVER ASSY, Aft power box	1	A
		(ATTACHING PARTS)		
	NAS601-5P	. SCREW, (Optional NAS601-5)	4	A
	MS21042L06	. NUT, (Optional BACN10BY506W)	4	A
		-------*-------		
3	29-5979-4	. . HINGE, Aft battery power box cover (altered from AN257-5-9)	1	A
4	36-3165	. . GASKET, Aft battery power box (altered from BAC1521-287)	1	A
5	26S8-5	. . STUD ASSY, Quick release fastener (71286) (BACS21Y5R)	2	A
6	2600SW	. . WASHER, Stud retaining (71286) (BACW10X2)	2	A
7	BACG20AA-1	. . GROMMET, Quick release fastener	2	A
8	BACM10B31-8AY	. . METAL-CAL, "J-79 Power Box Aft Battery"	1	A
9	BACM10W42-2UG	. . METAL-CAL, "Warning 28 Volts DC"	1	A
10	3967	. FUSEHOLDER, 10-30 amp (71400)	2	A
		(ATTACHING PARTS)		
	NAS514P1032-10P	. SCREW	4	A
		------*------		

Figure 2-11L. Circuit breaker assembly.

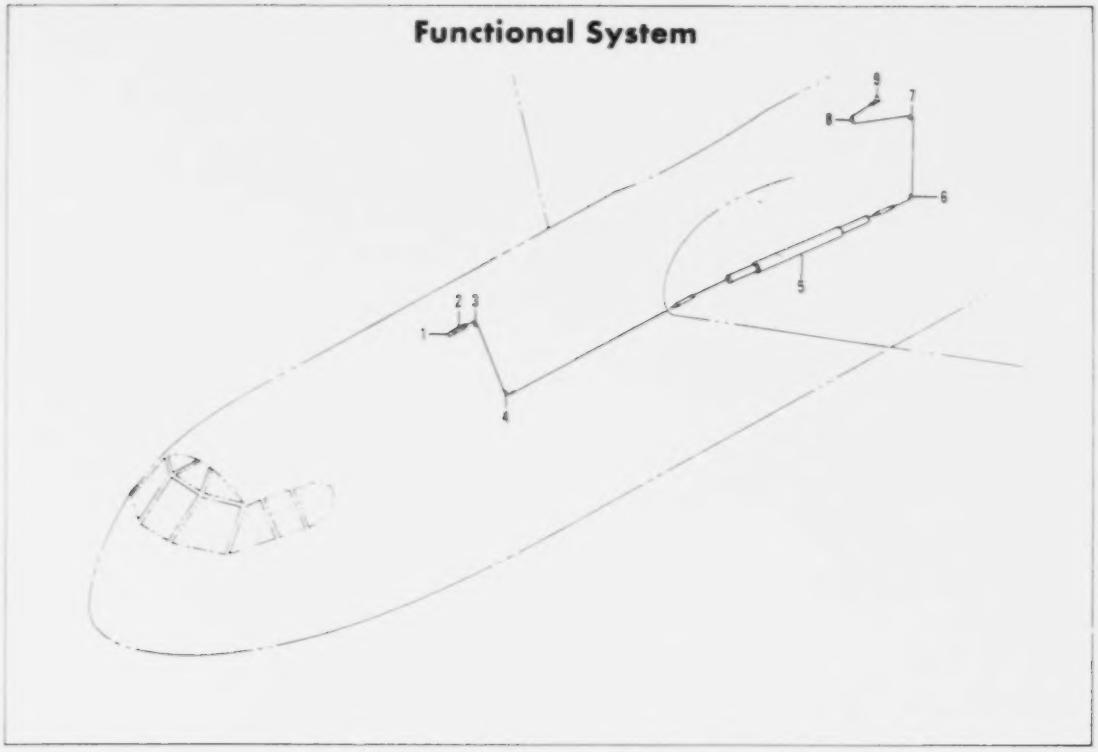

Figure 1604. Life Raft Release Control System

Figure and Index Number	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	Units per Assembly	Usable on Code
1604		LIFE RAFT RELEASE CONTROL SYSTEM		
1	5-53869-1	. CONTROL INSTL, Life raft release (see fig. 485)	Ref	
2	5-57226	. SUPPORT INSTL, Life raft release handle (see fig. 362)	Ref	
3	9-42745	. BRACKET INSTL, Station 371 life raft release pulley . . . . . (see fig. 376)	Ref	
4	5-57229	. PULLEY INSTL, Station 371 pressure door (see fig. 374) . . .	Ref	
5	5-53869-2	. CONTROL INSTL, Life raft release (see fig. 937)	Ref	
6	5-49091	. BRACKET INSTL, Station 694 life raft (see fig. 977)	Ref	
7	5-49215-2	. BRACKET INSTL, Station 694 life raft release (see fig. 977) .	Ref	
8	5-68256	. BRACKET INSTL, Station 655.35 life raft release (see fig. 978)	Ref	
9	5-63940	. LATCH INSTL, Life raft release (see fig. 928)	Ref	

Figure 2-11M. Life raft release control system.

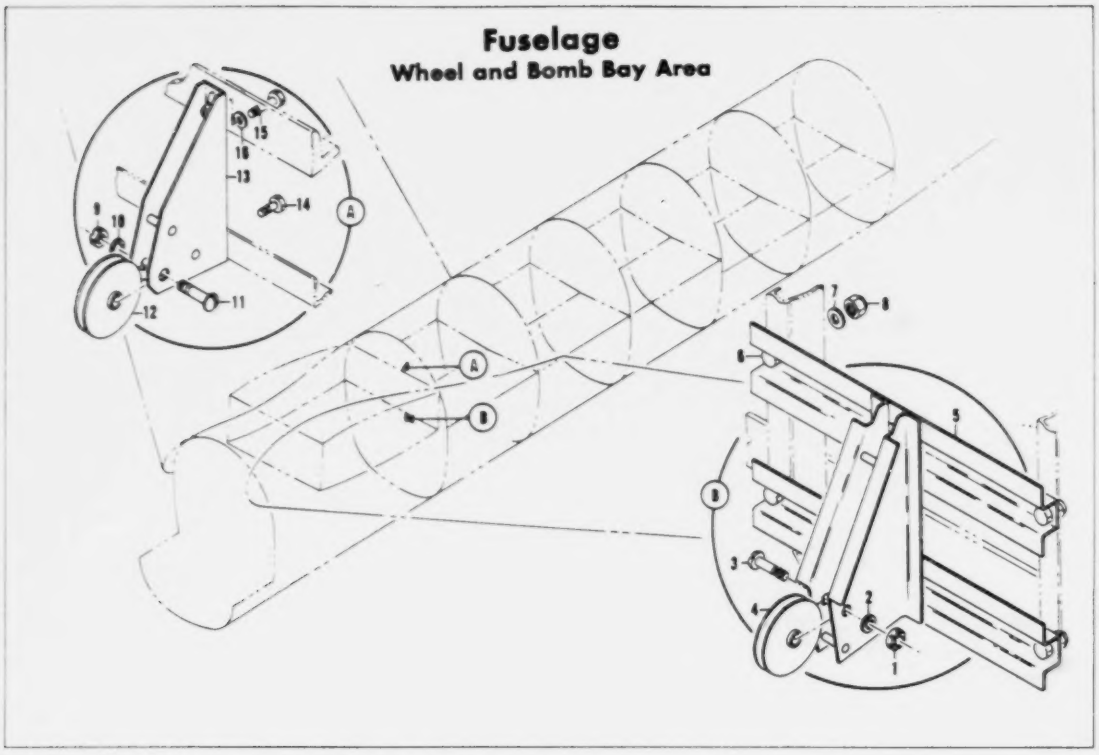

Figure 977. Station 694 Life Raft and Life Raft Release Bracket Installations

Figure and Index Number	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	Units per Assembly	Usable on Code
977		STATION 694 LIFE RAFT AND LIFE RAFT RELEASE BRACKET INSTALLATIONS		
	(a) 5-49091	. BRACKET INSTL, Station 694 life raft (see fig. 870-5 & 1604-6) .	Ref	
1	AN320-4	. . NUT	1	
2	AN960D416	. . WASHER	1	
3	AN24-14	. . BOLT	1	
4	NAS376-4	. . PULLEY	1	
5	9-36432	. . BRACKET ASSY, Station 694 life raft . . . . . (ATTACHING PARTS)	1	
6	AN3-4A	. . BOLT	4	
7	AN960D10L	. . WASHER	4	
8	AN365-1032	. . NUT	4	
		---------*---------		
	(a) 5-49215-2	. BRACKET INSTL, Station 694 life raft release . . . . . (see fig. 870-4 and 1604-7)	Ref	
9	AN320-4	. . NUT	1	
10	AN960D416	. . WASHER	1	
11	AN24-14	. . BOLT	1	
12	NAS376-4	. . PULLEY	1	
13	6-68505	. . BRACKET ASSY, Life raft release . . . . . (ATTACHING PARTS)	1	
14	AN3-4A	. . BOLT	1	
15	AN3-7A	. . BOLT	1	
16	AN960D10	. . WASHER	1	
		---------*---------		
		(a) deleted by T.O. 1B-52D-589		

Figure 2-11N. Bracket installation area.

Research Procedures III, Part Number Is Known. If you are fortunate to know the part number of a needed part or damaged part, your research procedures are relatively simple. The numerical index, figure 2-11J, is the place to start. Simply locate the part number in the numerical index. Across from the part number is given the figure number and index number. At this time, all you need to do is turn to the given figure number and obtain the information needed.

You must remember that no matter how small or how easy it is to make a replacement part, it is good practice to research all part numbers. The Air Force spends millions of tax dollars for replacement parts when they buy a new piece of equipment or aircraft, so why waste time and material fabricating a part, when there is the possibility that your Base Supply has one on hand. This is why it is important to always check the SMR codes.

Exercises (419b):

1. Why is it sometimes necessary to refer to the major assembly breakdown of the aircraft when using the –4IPB TO?

2. Why is it still necessary to refer to the numerical index of the –4IPB TO when you know the part number of a needed part?

3. What is obtained from the table of contents if you already know the location of the replacement part on the aircraft and the series of figures that relate to that section of the aircraft?

4. Besides an overall view of a function system, what other information is given on a functional system figure that makes it necessary to refer during research procedures?

5. Why is it required to refer to Section I of –4IPB TO after the figure and index number for the needed part is located in Section II of the –4IPB TO?

420. State the basic principles of repair and give examples of the methods used to maintain these principles.

Methods of repairing structural portions of the aircraft are numerous and varied. Information about the design load acting in various structural parts of the aircraft are not always available to the field repairman. This is one reason why the problem of repairing a damaged section is ususally solved by duplicating the original part in strength, kind of material, and dimensions. Accordingly, the maintaining of original strength, weight, and proper contour must be foremost in your mind when you are making any repair.

Maintaining Original Strength. As you make a repair, you must observe certain fundamental rules so that the original strength of the structure can be maintained. Thus, make the patch plate have a cross-sectional area equal to, or greater than, that of the original damaged section. Again, if the member is subjected to compression or to bending loads, place the splice on the outside of the member in order to secure a higher resistance to such loads. If, however, you cannot place the splice in the outside of the member, use material of a weight next heavier than the weight of the material used in the original.

REMEMBER: Maintaining original strength is your main concern as you make any repair.

Material selection. Be sure that the material used in all replacements or reinforcements is similar to the material used in the original structure. If it is necessary for you to substitute an alloy weaker than the original, use material of a heavier gage to give an equivalent cross-sectional strength. Never practice the reverse; that is, never substitute a lighter gage, stronger material for the original. The reason for this apparent inconsistency is that one material can have greater tensile strength than another, but less compressive strength, or vice versa, as shown in the comparison of mechanical properties of alloys 2024T and 2024–T80.

Consider the substitution of alloy 2024T for alloy 2024–T80. Here the substitute material will have to be thicker unless the reduction in compressive strength is known to be acceptable. On the other hand, what if 2024–T80 material were substituted for 2024T stock? Here the substitute material will have to be thicker unless the reduction in tensile strength is known to be acceptable. Similarly, the buckling and torsional strength of many sheet metal and tubular parts are dependent primarily upon the thickness rather than the allowable compressive and shear strengths of the material. Therefore, a substitute thinner than the original will reduce considerably the buckling and torsional strength of a part, even though the thinner substitute material has higher compressive and shear strengths. You will find information on aluminum alloy sheet substitution in TO–1–1A–1, *General Manual for Structural Repair.*

When forming is necessary, be particularly careful. Heat-treated and cold-worked alloys will stand very little bending without cracking. Soft alloys, on the other hand, are easily formed but are not strong enough for primary structures. Strong alloys can be formed in their annealed condition and heat-treated to develop their strength before assembling.

In some cases, if the annealed metal is not available, you can heat the metal, quench it according to regular heat-treating practices, and form it before age-hardening sets in. The forming should be completed in

about half an hour after quenching or the material will become too hard to work. If you use a brake to form a section, place a thin piece of soft metal over the brake jaws to prevent scraping and scratching the surface of the sheet.

Fastener selection. You must consider a number of factors when selecting the correct fastener for a repair, including the following:

a. Areas of Application. The area on the aircraft where the repair is being made has a direct bearing on the type of fasteners required. For example, damage in an "open" area (access to the backside is unlimited) normally requires solid rivets. In contrast, in a "blind" area (access to the backside is not possible), a blind fastener is used.

b. Head Style. Concerning head style, you should consider the aerodynamic smoothness factor, based on limits outlined in the applicable -3 technical manuals.

c. Function of the damaged part. If the repair is located in a pressuruzed or fuel tank area, you need to give special consideration to the type of fastener used.

d. Diameter of rivets. Two methods exist for determining the diameter of the rivet required. In the first method, you determine the size of rivets by referring to the rivets (used by the manufacturer) in the next parallel rivet row inboard on the wing or forward on the fuselage. The other method of determining the size of rivets to be used is to multiply the thickness of the skin by 3 and use the nearest larger sized rivet corresponding to that figure. Thus, for example, if the skin thickness is 0.040 inch, multiply 0.040 by 3, which equals 0.120, and use the next larger size rivet, 1/8 inch (.125 inch).

e. Number of rivets required. All repairs made on structural parts of aircraft require a definite number of rivets in order to restore the original strength. This number varies according to the thickness of the material being repaired and the size of the damage. You can determine the number of rivets or bolts required by referring to a similar splice made by the manufacturer, or by using the following rivet formula: The number of rivets to be used on each side of the break is equal to the *length of the break* times the *thickness of the material* times 75,000 divided by the *shear strength* or *bearing strength* (whichever is the smaller of the two).

Now look at each separate term in this formula. In the order given:

- The *length of the break*—This is measured perpendicular to the direction of the general stress running through the damaged area.
- The *thickness of the material*—This refers to the actual thickness of the piece of material being repaired, and it is measured in thousandths of an inch.
- The 75,000 figure—As used in the formula, this assumes a stress load value of 60,000 psi and then increases this by a safety factor of 25 percent. It is a constant value.
- The *shear strength*—Taken from table 2-1, this is the amount of force required to cut a rivet holding two or more sheets of material together. Accordingly, if the rivet is holding two parts, it is under *single* shear; whereas if it is holding three sheets or parts, it is under *double* shear. NOTE: To determine the shear strength, you must know the diameter of the rivet to be used.
- The *bearing strength*—This is a value taken from table 2-2. It is the amount of tension required to either pull a rivet through the edge of two sheets riveted together or to elongate the hole. Note here that you must know the diameter of the rivet to be used and the thickness of material being riveted to use the bearing strength chart correctly. The diameter of the rivet would be the same as that you have used when determining the shear strength value. Thickness of material would be that of the material being repaired.

All right, let's assume that you now understand the derivation and meaning of each term used in the rivet formula (if not, read again the preceding paragraphs). You can reduce the formula to the following:

$$\frac{L \times T \times 75{,}000}{S \text{ or } B}$$

TABLE 2-1
SINGLE SHEAR STRENGTH TABLE

*Single Shear Strength of Aluminum-Alloy Rivets (Pounds)									
Composition of Rivet (Alloy)	Ultimate Strength of Rivet Metal (Pounds Per Square Inch)	Diameter of Rivet (Inches)							
		1/16	3/32	1/8	5/32	3/16	1/4	5/16	3/8
2117 T	27,000	83	186	331	518	745	1,325	2,071	2,981
2017 T	30,000	92	206	368	573	828	1,472	2,300	3,313
2024 T	35,000	107	241	429	670	966	1,718	2,684	3,865
*Double shear strength is found by multiplying the above values by 2.									

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truding head rivets, (2) standard flush rivets in dimpled holes, and (3) standard flush rivets in countersunk holes, if driven high and shaved.

Intermediate sealing. An "intermediate seal" is obtained when all holes, joggles, seams, and slots in the seal plane have been sealed. Here fasteners do not require sealing.

Limited sealing. A "limited seal" is obtained when all holes, slots, and joggles in the seal plane have been sealed. Seams and fasteners do not require sealing when this sealing level obtains.

Environmental Sealing Types. Sealing is further grouped according to the type of environment encountered. Thus the eight types described in the following paragraphs exist. Each of these types may be placed within one of the four sealing classification levels that follow.

Fuel sealing. "Fuel sealing" is used to confine or control either liquid fuel or fuel vapor within a defined area. In a fuel-sealed area, the sealant must be fuel resistant. For example, liquid fuel sealing falls into the absolute sealing classification; whereas fuel vapor is classified as intermediate sealing.

Pressurized area sealing. "Pressure sealing" is used to maintain a required pressure within a defined area. This is an allowable leakage type of sealing; however, proper application of sealants should keep leakage small enough so that correct cabin pressure can be maintained at high altitude. Note that while "cabin area sealing" falls into the extensive sealing calssification, "aerodynamic balance sealing of the empennage" is classed as limited sealing. In further contrast, "aerodynamic sealing area in the wing" is classified as intermediate sealing. In pressure-sealed areas, the sealant is always applied to the pressure side of the structure.

Weather sealing. "Weather sealing" is used to insure adequate protection from moisture, dust, and rain. It generally falls within the intermediate level. The entire exterior surface of the aircraft is sealed by application of aerodynamic smoother, which is applied to all skin joints and fasteners. However, various compartments and doors, particularly those found along the upper fuselage surface, are sealed internally.

Firewall sealing. "Firewall sealing" is used to restrict the passage of flames through the seal plane. This type is classified as absolute, intermediate, and limited, according to the area where it is used. Materials used for this type of sealing are exceedingly critical.

Electrical sealing. "Electrical sealing" is used to prevent leakage of fuel, fuel vapor, or pressurized air from a sealed area; to prevent fuel or fuel vapor from entering connectors and compartments where arcing might occur; and to prevent dust and water from entering connectors and electrical components; thus causing corrosion. Materials used for this type of sealing are dependent upon the environmental location of the seal.

Acid-resistant sealing. "Acid-resistant sealing" and acid-resistant finishes are used to prevent any corrosion solution of battery electrolyte or uric acid from contacting the structure. Acid sealing is classified as absolute sealing.

Window sealing. "Window sealing" is a combination of pressure sealing, weather sealing, and aerodynamic smoothing.

High-temperature sealing. "High-temperature sealants" must be used in those areas where operating temperatures exceed 93° C. (200° F.). These include engine pods, anti-icing ducts and adjacent structure, engine air bleed lines to air conditioning turbines, and areas adjacent to various electronic equipment.

Exercises (447):

1. In the space provided in front of each type of sealant requirement, place the classification of sealing level required:

   _____ a. Weather sealing.
   _____ b. Fuel vapor sealing.
   _____ c. Liquid fuel sealing.
   _____ d. Cabin pressurized sealing.
   _____ e. Acid sealing.

2. Which of the classifications of sealing levels does *not* require that seams be sealed?

448. Associate a series of sealing terms with their definitions and state the TO clarifying sealing terms and expressions.

Sealing Terms. As an airframe repair specialist, you need to be familiar with those sealing terms commonly used to describe materials and procedures for maintaining general aircraft sealing. For that reason, the following list is given.

Sealant. This is a mixture of base compound and accelerator used to cure a firm fuel-, acid-, or water-resistant material.

Accelerator. "Accelerator" is an internal curing agent for sealants.

Base Compound. The major component of sealant material used with accelerator to produce a fuel-, acid-, or water-resistant sealant is called "base compound."

Seal Plane. This refers to the interior surfaces of a tank, tank cavity, or pressurized compartment—comprized of structure, integrally sealed fasteners, and sealant—which actually contains the liquid or pressurized air.

Primary seal. The "primary seal" is that sealant applied to a structure which becomes a part of the seal plane.

Secondary seal. Sealant applied behind and in conjunction with primary sealing to confine liquid or pressurized air is known as "secondary seal."

Backup seal. "Backup seal" is a secondary seal which supports a primary seal.

Repair seal. A seal placed for the purpose of limiting the amount of sealing required to repair a leak is referred to as "repair seal."

Faying surface seal. A "faying surface seal" is a seal effected by the sandwiching of sealant between mating surfaces of assemblies.

Injection seal. You have an "injection seal" when dealing with the filling of holes or channels by the forcing of sealant into a void or cavity to obtain a primary or backup seal.

Fillet. This is a bead of sealant applied along structural junctions or seams.

Re-entrant fillet. A "re-entrant fillet" is an overlapping quantity of sealant not in close contact with adjacent sealant or structure.

Top coat. The "top coat" is, of course, a continuous film of material which provides sealant protection from fuel and corrosion protection for metal surfaces.

Tack-free time. That point of time in the curing of a sealant or top coat at which the material does not stick when a dry knuckle is pressed lightly against the sealant or top coat and withdrawn is spoken of a "tack-free time."

You can obtain clarification of additional terms and expressions to the foregoing by looking into Section II, of TO 1-1-3, *Preparation Inspection and Repiar of Aircraft Fuel, Oil and Water Alcohol Cells and Integral Tanks.*

Exercises (448):

1. In the space provided in front of each definition in column A, place the number of the term given in column B which matches the definition. Note: Each item in column B matches once or not at all.

Column A	*Column B*
___ a. Internal curing agent for sealants.	1. Primary seal
___ b. A bead of sealant applied along structural junctions or structure.	2. Secondary seal
___ c. A seal effected by the sandwiching of sealant between mating surfaces.	3. Top coat
___ d. Sealant applied to structure which becomes a part of the seal plane.	4. Accelerator
___ e. The major component of sealant material.	5. Seal plane
___ f. Sealant forced into a void or cavity to obtain a primary or backup seal.	6. Faying surface seal
___ g. That which protects sealant from fuel.	7. Fillet seal
	8. Backup seal
	9. Base compound
	10. Injection seal

2. What technical order contains clarification of sealant terms and expressions?

449. Cite specific details of the procedures used to inspect and remove defective sealant seals and give the steps in resealant removal.

Sealant Defects. Pressure tightness of an area of section is checked before and after a repair is made. Ground pressurization is accomplished by filling the section with air from an external source through ground pressure testing fittings.

With the section pressurized to a given pressure, you may locate leaks on the outside of the aircraft by applying a soapless bubble fluid to all joints and seams in the suspected area. Air bubbles will clearly pinpoint for you the general area of the leakage. You may also isolate a specific leak on the inside of the aircraft by passing the free end of a stethoscope, or a similar listening device along the seams in the leakage area. When you do this, you can detect the leak by the change in sound when the instrument passes over it. After completing the test, remove the soapless bubble fluid from the outside of the aircraft by washing the surface with clear water to prevent corrosion.

Precautionary measures. Here are a few precautionary measures you should follow during the testing procedure:

a. When there are personnel inside the area, *never* pressurize it to a pressure higher than has been previously established during testing with the section empty.

b. Do not allow any person who has a cold or who has recently had one, or whose sinuses are impaired in any way to work inside the pressurized section.

c. Have a qualified operator present at the pressurization equipment control panel at all times while the section is being pressurized. If the cockpit is being pressurized, have all personnel stand clear of the canopy.

Necessary repair or replace conditions. Pressurization may not always be necessary to determine sealant defects. Indeed, you should see that sealants are either repaired or replaced when the following conditions are present:

a. Sealant is pealed away from the structure.
b. Seams are exposed through fillet seal.
c. Fillet or hole filling sealant is exposed through coating.
d. Sealant is damaged because of removal and installation of fasteners, access doors, or other sealed parts.
e. Crack or abrasions exist in the sealant.
f. Air bubbles appear in the sealant (air bubbles will expand at high altitude, resulting in damage to the seal).
g. Leakage occurs between sealed faying surfaces.

Sealant removal. When engaged in sealant removal and fairing be sure that the tools you use are locally manufactured. They should be of the sizes and shapes shown in figure 5-9. The materials used in their manufacture should be hardwoods, with metal as an alter-

Answers for Exercises

CHAPTER 1

Reference:

400 - 1. Drilling only one or two holes and when a power unit for a pneumatic (air) drill is not available.
400 - 2. Because most of the work an airframe repairman will do is located around flammable materials.
400 - 3. For drilling holes when a high degree of accuracy is required.
400 - 4. When the V-belts will deflect approximately 1/2 inch.
400 - 5. Goggles.

401 - 1. Overheating the twist drill.
401 - 2. Because the metal may crack.
401 - 3. No. The higher the twist drill number, the smaller the diameter of the twist drill.
401 - 4. The lips.
401 - 5. They allow the chips to escape, plus also allow the lubricant to flow easily down to the lips.
401 - 6. The web.
401 - 7. To smooth and enlarge holes to exact size.
401 - 8. They are very brittle.
401 - 9. Because they are used to complete the reaming of blind holes.
401 - 10. Expansion type reamers.

402 - 1. To sharpen the other cutting ip.
402 - 2. As many times as needed to obtain a perfect point.
402 - 3. This depends on the person grinding the twist drill.
402 - 4. By grinding the web on a thin, round, or beveled edge grinding wheel.
402 - 5. Cutting edges — check to see if both are the same length and desired angle.

403 - 1. Center punch indentation not deep enough.
403 - 2. After the hole is completely drilled.
403 - 3. 90° from the working surface.
403 - 4. Either the drill was off center when drilling or the drill was tilted when it was withdrawing from the hole.
403 - 5. A countersink or a larger twist drill than the hole.
403 - 6. Predrilling is drilling holes first slightly undersize, then to the original size.
403 - 7. 1/8.
403 - 8. No. Rivet holes must have a clearance of 0.002 to 0.004 thousandths.
403 - 9. Use Clecos.
403 - 10. For quick identification of different diameter sizes.

404 - 1. The angles in the countersunk rivets and diameter of the hole to be countersunk.
404 - 2. 0.001.
404 - 3. Countersink only material that is twice as thick as the countersunk portion of the rivet being installed.
404 - 4. Any four of the following will be correct:
Tipping the countersink to one side, oversized rivet holes, undersized countersink pilots, improper use of the countersink, a countersink in poor condition, countersink not running true in the chuck of the drill and lack of backside guide for the pilot on the countersink.
404 - 5. The thickness of the material.

405 - 1. To allow for springback.
405 - 2. When a countersunk rivet is used as the male dimpling die and a regular female die is used together to form dimpled holes.
405 - 3. Use the original rivet used to dimple the hole.
405 - 4. After the dimpling is completed.
405 - 5. The construction of the female die.
405 - 6. Facilitates removal of the metal after the dimple has been made.
405 - 7. The male die will enlarge and ruin the coining ram.
405 - 8. Because of possible hard spots in the metal.
405 - 9. Because the heating range of the machine is not high enough to effect dimpling.
405 - 10. Dimple the material when the thickness of the material is thinner than the thickness of the rivet head. For thicker material countersink the holes.

406 - 1. Nonstructural.
406 - 2. Diameter, length, and angle of countersink.
406 - 3. When high strength is required.
406 - 4. The head of the shear head countersunk rivet is smaller in diameter and thinner than the standard countersunk rivet.
406 - 5. Monel.
406 - 6. One-to-one.
406 - 7. More rivets are required in the area.
406 - 8. Only when the required countersunk rivet is not available and it is accomplished by driving the universal head from the opposite side and upsetting the shank in the countersunk recess (nest).
406 - 9. The hole of the standard countersunk rivet would be too large for the material.
406 - 10. A standard countersunk rivet of the same diameter as the shear head rivet, the head of the standard rivet is microshaved to proper smoothness.

407 - 1. Head markings.
407 - 2. a. B.
b. D.
c. AD.
d. DD.
e. M.
407 - 3. a. Military Standard.
b. Head style.
c. Material code.
d. Diameter in one thirty-seconds of an inch - (1/8).
e. Length in one-sixteenth of an inch - (5/8).
407 - 4. TO 1 1A 8, *Structural Hardware*.
407 - 5. Material composition of the rivets in the boxes.

408 - 1. Material composition of the rivet.

408 - 2. The type of heating equipment used.
408 - 3. 24 hours.
408 - 4. 20 minutes.
408 - 5. To delay the age hardening process as a result of the heat-treatment.

409 - 1. A 1/8 universal rivet set.
409 - 2. Flat.
409 - 3. 6 lbs.
409 - 4. 5/32.
409 - 5. 2.
409 - 6. 0.008.
409 - 7. 1 inch.

410 - 1. Allowing the bucking bar to vibrate in unison with the gun set.
410 - 2. 2 to 3 lbs.
410 - 3. Driving the shank end of the end of the rivet with a handset and a hammer and bucking the manufactured head with a handset held in a vise or a bottle bar.
410 - 4. When the rivet gun stops hammering.
410 - 5. ½ diameter high, 1½ diameter in width.
410 - 6. Placing shims under the end sets of both jaws.
410 - 7. The rivet's diameter.
410 - 8. Excessive hammering.
410 - 9. To temporary correct an unsatisfactory cupped condition on a rivet set.
410 - 10. The material may have become bulged towards the shop head.

411 - 1. Shear, bearing, and head.
411 - 2. When rivets are excessively strong in shear.
411 - 3. Tension.
411 - 4. They become overloaded.
411 - 5. Head failure.

412 - 1. Checking the formed shop head for proper dimensions.
412 - 2. Check to see if the rivet is flush with the surface.
412 - 3. Shifted or loose rivets.
412 - 4. Inspection of the rivet shank.
412 - 5. So that the hole will retain its original size and shape.
412 - 6. It is more symmetrical and there is less chance of damaging the rivet hole or the material around it.
412 - 7. One size smaller than the rivet diameter.
412 - 8. One-half the thickness of the top sheet.
412 - 9. Provide some type of backside support.
412 - 10. Because of the dimple in the head.

CHAPTER 2

413 - 1. Misalignment, cracks, and broken or missing tangs.
413 - 2. Deformation of bolt and elongation of the hole.
413 - 3. Fluorescent penetrant inspection should be performed.
413 - 4. Metallic ring test.
413 - 5. Pockets and corners where moisture may accumulate.

414 - 1. Patching.
414 - 2. Neligible.
414 - 3. Insertion.
414 - 4. Replacement.

415 - 1. Temporary.
415 - 2. One-time flight.
415 - 3. Permanent.
415 - 4. Combat repair.

416 - 1. Title page.
416 - 2. "A" page.
416 - 3. List of illustrations.
416 - 4. Section 1.
416 - 5. At the beginning of the particular section.

417 - 1. Make sure your using the correct TO.
417 - 2. The sections within the TO.
417 - 3. If specific illustration is given, then your research procedures are simple, but if a repair illustration isn't given, then further research is necessary.
417 - 4. Check the table of contents, looking for a breakdown index of the section so tha tyou can pinpoint the area within the section containing the damaged section.
417 - 5. Because additional research procedures may be required.

418 - 1. WL 302.
418 - 2. STA 130.
418 - 3. 6.60.
418 - 4. NAC. WL 100.
418 - 5. Rivets.
418 - 6. 3/16.
418 - 7. Universal.
418 - 8. 2017 T3.
418 - 9. 090 Clad 7075 T6.
418 - 10. BAC 1506 993.

419 - 1. TO 1-1A-1.
419 - 2. TO 1-1A-8.
419 - 3. TO 1-1A-9.
419 - 4. TO 1-1A-12.
419 - 5. TO 1-1A-8.

419a - 1. Item to be manufactured or fabricated at intermediate maintenance level.
419a - 2. This is a vendor's code. In this case the vendor is Dow Corning Corp, Midland, MI 48641.
419a - 3. The part is applicable to all Air Force serial number aircraft covered by the breakdown.
419a - 4. The part is removed, replaced, and used at depot only.
419a - 5. The letter L.
419a - 6. The part required special handling or condemnation procedures because of a specific reason.
419a - 7. A vendor number for which a comparable Boeing Standard number has been assigned.
419a - 8. PA—part is procurable and stocked; F—part is removed and replaced at the intermediate maintenance level; Z—part is nonrepairable, no repair is authorized; and Z—part is condemned and dispose at the intermediate maintenance level.
419a - 9. A difference exists between the IPB and the production drawings because of a modification.
419a - 10. The last given part number is used for the same item.

419b - 1. To locate the individual section of the aircraft where the replacement part is needed.
419b - 2. To obtain the figure and index number for ordering purposes and to check the SMR codes.
419b - 3. The specific figure within the individual section is obtained.
419b - 4. Besides the location of individual parts within the system, a reference figure for each individual part is also shown.
419b - 5. To interpret the SMR coding letters.

420 - 1. Maintaining original weight, contour, and weight.
420 - 2. The patch plate must have a cross-sectional area equal to, or greater than, that of the original damaged section.
420 - 3. Use material of a heavier gage to give equivalent cross-sectional strength.

420 - 4. By using what the manufacturer used is one way. The other way is to multiply the thickness of the skin by 3 and use the nearest larger sized rivet corresponding to that figure.
420 - 5. Length of the break, thickness of the material, shear strength, and bearing strength.
420 - 6. Reduction.
420 - 7. Control surfaces.

421 - 1. Aerodynamic smoothness.
421 - 2. If the damaged area is near or over a substructural member.
421 - 3. As reinforcement.
421 - 4. When the function of the part or the function of the part closeby requires a flush surface.
421 - 5. A combination repair is when both an exterior and an interior part are damaged in the same area.

422 - 1. Without a clear-cut definition of the problem, you and your worker may not be striving for the correct solution.
422 - 2. Fellow workers and supervisors can be consulted.

CHAPTER 3

423 - 1. Location of existing fasteners and allowance for the fastener spacing required in the filler and doublers.
423 - 2. Areas where a substructural member is not near the cut-out area.
423 - 3. Corner radii.

STOP -

1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.

2. USE NUMBER 2 PENCIL ONLY.

53153 03 21

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

REPAIR PROCEDURES

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if a all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DONT'S:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed*. Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

Multiple Choice

1. (400) When assigned to drill holes requiring close tolerances, which of the following should give the best results?

   a. Hand drill.
   b. Drill press.
   c. Portable pneumatic drill.
   d. Angle extension drill.

2. (400) Which type of drill should be used when making repairs near flammable material?

   a. Hand.
   b. Electric.
   c. Portable pneumatic.
   d. Grounded electric.

3. (401) The flutes on twist drills are necessary because they

   a. provide a means of chip removal.
   b. reduce the weight of the twist drill, permitting higher cutting speeds.
   c. cool the material being drilled as the twist drill is rotated.
   d. prevent the twist drill from overheating when deep holes are drilled.

4. (401) Which type of reamer should be used for efficient reaming with the least amount of chatter?

   a. Straight.
   b. Bottom.
   c. Spiral.
   d. Expansion.

5. (402) When using a drill-holding fixture to sharpen a twist drill, at what point is it necessary to rotate the twist drill one-half turn in the V-blocks?

   a. Before completing the first cutting arc.
   b. After completing the first cutting arc.
   c. When releasing the twist drill after all cutting arcs are completed.
   d. When readjusting the tailstock after the first cutting arc is completed.

6. (402) During free-hand grinding of twist drills, how is the centerline of the drill positioned in relation to the cutting surface of the grinding wheel?

   a. Perpendicular with the shank slightly higher than the heel.
   b. Parallel with the shank slightly lower than the heel.
   c. Angled to the desired cutting degrees with the heel slightly higher than the shank.
   d. Angled to the desired cutting degree with the shank end lowered slightly.

7. (403) How much smaller should the diameter of a pilot drilled hole be than that of the finished hole?

   a. 1/2 the diameter of the final hole size.
   b. 1/4 of the thickness of the material being drilled.
   c. 1/64th of an inch.
   d. 1/16th of an inch.

8. (403) A twist drill used for hard metals should have an included angle of

   a. 45°.
   b. 90°.
   c. 118°.
   d. 136°.

9. (403) The color of the Cleco fastener used when drilling fastener holes is directly related to the

   a. material composition of the rivet being installed.
   b. thickness of the materials being clamped together.
   c. type of material being drilled.
   d. diameter of the rivet being installed.

10. (404) When using a microstop countersink, each increment of the micrometer adjustment will increase or decrease the depth of cut by what fraction of an inch?

a. 0.0001.
b. 0.001.
c. 0.0002.
d. 0.002.

11. (405) Rivet holes that are to be dimpled using hand dimpling dies should be drilled

a. to the correct size after dimpling.
b. to the correct size before dimpling.
c. undersize so they will expand during the riveting operation.
d. oversize to allow for the expansion of the rivet shank during the riveting operation.

12. (405) Which of the following makes the coin dimpling method superior to the radius dimpling method?

a. The concave shape of the female die.
b. The sliding coining ram in the male die.
c. The 2° slope of the pilot on the male die.
d. The sliding coining ram of the female die.

13. (405) Corrosion-resistant steel is cold dimpled because

a. it is tough.
b. it has low formability qualities.
c. hot dimpling may produce hard spots in the metal.
d. the temperature range of the heating unit is not high enough to affect dimpling.

14. (406) Which rivets should be used where weight, shank, and hole tolerances are critical?

a. Monel.
b. Magnesium.
c. Stainless steel.
d. Titanium.

15. (406) Which of the following aluminum alloys are the least likely to corrode when riveted together?

a. 3003 and 2017.
b. 3003 and 7075.
c. 3003 and 5052.
d. 3003 and 2117.

16. (406) Approval of replacing "AD" rivets with "D" or "DD" rivets on a one to one basis is normally permissible except in

a. high strength areas.
b. formed structural members.
c. fuel or pressurized areas.
d. casting or fitting assemblies.

17. (407) Of the following rivet part numbers, which identifies a 100° countersunk aluminum rivet, which is 1/8 of an inch in diameter and 5/8 of an inch long?

a. MS20426-AD-4-10.
b. MS20470-AD-10-4.
c. MS20426-AD-10-4.
d. MS20470-AD-4-10.

18. (407) The head marking for carbon steel rivets consist of a

a. recessed double dimple.
b. raised double teats.
c. raised double dash.
d. recessed triangle.

19. (408) After heat-treating, how long can 2017- and 2024-T4 rivets be refrigerated before needing to be heat-treated again?

a. 20 minutes.
b. 1 hour.
c. 12 hours.
d. 24 hours.

20. (409) The temperature range for heat-treating aluminum rivets is 920° to 950°. The specific temperature depends on the

a. diameter of the rivet.
b. type of heating equipment used.
c. overall length of the rivet.
d. material composition of the rivet.

21. (409) When using a rivet cutter, if you need to reduce the length of a rivet from 1 inch to 1/2 inch, how many shims should be used on the rivet?

a. 2.
b. 4.
c. 6.
d. 8.

22. (409) If after installing a flush rivet, the manufactured head protrudes 0.008 of an inch above the skin surface, how many thousandths of an inch can be removed from the rivet head with a microshaver without damaging the skin surface?

a. .002.
b. .004.
c. .006.
d. .008.

23. (410) When installing rivets, coordinating bucking is defined as

a. having an efficient signal system.
b. allowing the bucking bar to vibrate in unison with the gun set.
c. reducing the bucking pressure as the shop nears completion.
d. allowing the rivet gun to hit a few more times after the bucking bar is removed.

24. (410) If the rivet you are driving is going "clubhead," you should

a. use reverse riveting.
b. use the process called coordinated bucking.
c. remove the rivet and start over.
d. move the bucking bar across the rivet in the opposite direction.

25. (410) Squeeze riveters that are not equipped with a gap regulator are adjusted by

a. using oversized end sets.
b. reversing the positioning of the end sets.
c. installing shims under the end sets of both jaws.
d. varying the length of the rivets being installed.

26. (411) The most common type of rivet failure is

a. head.
b. bearing.
c. shear.
d. compression.

27. (411) Which type of rivet failure is especially common in blind rivets?

a. Shear.
b. Bearing.
c. Head.
d. Compression.

28. (412) While inspecting installed rivets for structural efficiency, you notice rivets tipped in different directions. This is probably the result of

a. excessive loading along the rivets.
b. prior improper installation procedures.
c. longer rivets than necessary being installed.
d. excessive riveting pressure during riveting installation.

29. (412) Joggles in removed rivet shanks indicate that the

a. sheet failed in shear strength.
b. rivets are too small for the fastener holes.
c. rivets have failed in shear strength.
d. rivets have failed in compressive strength.

30. (413) Which of the following would require a closer inspection of the rivet within or near a damaged area?

a. Cracks in the paint around the rivet.
b. Rivet head tight against the surface.
c. A locking collar of a blind rivet, recessed within the manufactured head.
d. A stem missing from a pull-thru rivet.

31. (413) When inspecting damaged honeycomb panels, you should use the metallic ring test to check for

a. elongated fastener holes.
b. cracked hinge assemblies.
c. delamination and voids.
d. dents and gouges.

32. (414) Small cracks and dents in the outer skin of a fuselage would be classified as

a. negligible damage.
b. damage repairable by patching.
c. damage repairable by insertion.
d. damage necessitating replacement of parts.

33. (414) Damage to the structure of an aircraft which can be repaired by cutting away the damaged section, replacing the removed section with a like section, and securing the section with splices is classified as

a. negligible damage.
b. damage repairable by patching.
c. damage repairable by insertion.
d. damage necessitating replacement of parts.

34. (415) A repair that meets the original strength and aerodynamic requirements is classified as a

a. major repair.
b. permanent repair.
c. depot repair.
d. temporary repair.

35. (415) What classification of repair is the repair that restores a limited load-carrying capacity to a damaged structural member and allows the aircraft to be returned to a repair facility?

a. Limited repair.
b. Combat repair.
c. Temporary repair.
d. One-time flight repair.

36. (416) Which of the following is not found on the title page of a technical order?

a. Date of publication.
b. Latest date of revision.
c. List of repair figures.
d. Aircraft model and series numbers.

37. (416) After locating the proper repair figure in a technical order, where can you check to insure the repair figure is up-to-date?

a. "A" page.
b. Title page.
c. List of illustrations.
d. Table of content.

38. (417) What factor directly affects the amount of research necessary to locate specific repair procedures in a structural repair manual?

a. Type of rivets required in the repair?
b. Whether or not a repair illustration is given.
c. The time necessary to complete the reapir.
d. Type of technical order file being used by the researchers.

39. (418) Generally, fastener symbols are divided into four sections. The lower-left hand section indicates the

a. head style of the fastener required.
b. material composition of the fastener required.
c. fastener installation process.
d. number of fasteners required in the repair.

40. (419) Which TO manuals contains information on the various types of aircraft metals?

a. 1-1A-1.
b. 1-1A-8.
c. 1-1A-9.
d. 1-1A-12.

41. (419) Identification of aircraft structural hardware can be located in

a. TO 1-1A-1.
b. TO 1-1A-8.
c. TO 1-1A-9.
d. TO 1-1A-12.

42. (420) In making structural aircraft repairs, which of the following is not a primary concern?

a. Strength.
b. Contour.
c. Weight.
d. Appearance.

43. (420) The shear strength required for the fasteners used in a given repair is based on the

a. diameter of the fastener.
b. number of fasteners required.
c. area where the fasteners are to be installed.
d. diameter of the fastener times the length of the fasteners needed.

44. (421) In accordance with the -3 technical order, when is it permissible to install a non-flush repair on the outer fuselage surface of an aircraft?

a. When substructural members are being repaired.
b. Only if the patch plate restores the damaged area to its original contour.
c. When aerodynamic smoothness requirements are not critical.
d. Only if a flush patch exceeds the weight allowances for a given area.

45. (421) Which of the following determines the number of repair parts necessary in a flush repair?

a. Number of rivets required.
b. Location of substructural members.
c. Material compocition and thickness of the damaged area.
d. Direction of stress within the damaged part.

46. (422) The most important step in resolving a technical problem is to

a. insure only up-to-date technical orders are used for research purposes.
b. define and state the problem accurately.
c. follow-up after the problem is solved.
d. to use the technical problems as a training situation.

47. (423) In addition to removing all damage, what else should be accomplished when making a cutout?

a. Remove stress concentrations.
b. Stop-drill all cracks.
c. Anneal the cutout areas so the area will not be work-hardened during the cutout operation.
d. Maintain proper rivet pitch between existing fasteners.

48. (423) In planning the layout of a cutout, an "open area" refers to

a. the opening left after all damage has been removed.
b. an area without a substructural member in the damaged area.
c. space not previously damaged.
d. the spacing allowance between fasteners.

49. (424) When selecting a twist drill to use for chain drilling removal techniques, what factors should be considered in making the selection?

a. Size and location of the cutout area.
b. Material composition and thickness of the cutout area.
c. Location of existing fasteners within and outside the cutout area.
d. The diameter and head style of repair fasteners.

50. (424) When using a skin knife, why is it necessary to chain drill the corner radii of the cutout area?

a. It provides an area for inspection of the substructural members during the removal process.
b. The drilled holes reduce the wear of the cutting tip on the skin knife.
c. The depth of each cut made by the skin knife can be judged by checking the drilled holes.
d. Skin knifes are primarily designed for straight line cuts and the drilled holes serve as a stop when cutting.

51. (425) When making a skin cutout over a substructural member, which of the following cutting tools should you use to reduce the possibility of damaging the substructural member?

a. Hacksaw blade.
b. Reciprocating saw.
c. Skin knife.
d. Circular shaped rotary file.

52. (426) The location of existing fasteners near a damaged area must be taken into consideration when determining the

a. material thickness of the repair parts.
b. number of fasteners required for the repair.
c. overall dimensions of the cutout area.
d. classification of repair to be accomplished.

53. (426) In cases where both a skin cutout and a cutout on a substructural member are required, what determines which tools are used to make the cutout on the substructural member?

a. The location of repair fasteners.
b. The size of the cutout required on the substructural member.
c. The size of the skin cutout.
d. The existing fasteners located in both the substructural member and skin.

54. (427) If you space rivets too close to the edge of a sheet, the sheet is likely to

a. pull away from the rivets.
b. turn up at the edges.
c. turn under at the edges.
d. shear the head of the rivets.

55. (427) Rivet pitch refers to the

a. perpendicular distance between the rivet rows.
b. distance between the centers of neighboring rivets in the same row.
c. distance between rows in a two-row layout.
d. distance from the center of the first rivet to the edge of the sheet.

56. (428) Prior to developing a rivet layout for a circular flush repair what must be established?

a. Rivet pitch required on the filler plate.
b. The head style of the rivets to be used.
c. Direction of the stress concentrations within the part being repaired.
d. Location of the center point of the cutout area.

57. (428) If the location of rivets on the inner and outer rows of a layout pattern developed for a square flush patch are the same, it indicates that the

a. rivet pitch and transverse pitch are the same.
b. edge distance is beyond acceptable limits.
c. doubler is twice the size of the filler plate.
d. wrong measurements were used to develop the rivet pattern.

58. (429) Which of the following layout procedures is very important when developing a rivet pattern for a flush skin repair over a substructural member?

a. Locating the center lines of the cutout area to use as a starting point in the rivet layout.
b. Placement of the various lengths of rivets required in the repair because of the substructural member.
c. Determining the edge distance requirements for the different head styles of rivets.
d. Measurements of edge distance locations in relation to the width of the substructural member and the cutout area.

59. (429) When developing a rivet pattern for a flush skin repair across a substructural member, which rivet pitch do you select for calculating the transverse pitch?

a. Use the smallest rivet pitch available regardless of which side of the cutout area it was developed.
b. Use the existing rivet pitch for the fasteners in the substructural member.
c. Select the rivet pitch developed on one of the sides of the cutout, opposite the width of the substructural member.
d. Select the strongest rivet pitch possible based on the diameter of the rivets used in the repair.

60. (430) When fabricating a filler plate for a flush skin repair in an open area, what is the recommended technique to use in determining the overall dimensions of the filler?

a. Use the cutout area as a template.
b. Use the dimensions of a previously installed flush repair.
c. Measure the damaged area prior to making the skin cutout.
d. Multiply the length of the damage by the width of the damage and add the edge distance requirements to the number obtained.

61. (430) Which type of drilling is used to align fastener holes when fabricating repair parts?

a. Chain.
b. Pilot.
c. Back.
d. Angle.

62. (431) Which method is considered to be the most accurate in locating blind fastener holes?

a. Scale.
b. Hole finder.
c. Measuring.
d. Plastic template.

63. (431) Prior to developing the fastener layout on a reinforcement plate used in a non-flush repair, you should

a. indicate on the reinforcement plate the outline of the damaged area.
b. trace the outline of the reinforcement plate on the part being repaired.
c. trim the reinforcement plate to the required overall dimensions.
d. taper the edges of the cutout area on the part being repaired.

64. (432) When replacing a new skin panel, the preferred method of determining the size and shape of the new skin panel is to

a. measure the opening of the aircraft.
b. use the skin scribe method of panel replacement.
c. back-drill all fastener holes into an oversize piece of metal.
d. use the old skin panel as a template.

65. (432) The degree of accuracy obtained when back-drilling fastener holes into a new skin panel is determined by all of the following except the

a. depth of the center punch.
b. alignment of substructural members.
c. angle at which the drill is held in relation to the skin panel surface.
d. pressure used to hold the new skin panel against the substructural members.

66. (433) The splice angle used in repairing a 90° stringer must have a bend radius

a. smaller than the stringer filler.
b. larger than the stringer filler.
c. equal to the original stringer.
d. equal to both the original stringer and stringer filler.

67. (434) In addition to the amount of damage to each member, what other factor must be considered when determining the size of the cutouts for a combination repair?

a. The type of cutting tools to use.
b. The material composition of the damaged parts.
c. The location of existing fasteners in each part.
d. The thickness of the parts being repaired.

68. (434) When are the fastener holes for the repair parts used in a combination repair, drilled to the required diameters?

a. Prior to installation.
b. During the fabrication procedures.
c. Prior to fabrication procedures.
d. After countersinking or dimpling is completed.

69. (435) A skin scribe used to outline an aircraft replacement filler should be made of

a. wood.
b. plastic.
c. glass.
d. steel.

70. (436) Zinc chromate primer is a

a. pre-cleaning agent used prior to using MEK.
b. cleaning solvent used prior to painting.
c. corrosion preventative used prior to the installation of repair parts.
d. bonding agent used on repair parts to provide a base for a corrosion preventative.

71. (436) During the riveting of repair parts, why is it recommended that the first few rivets be randomly spaced throughout the fastener layout?

a. To see if the rivet gun is adjusted properly for the diameter of the rivet being installed.
b. To see if the proper length rivets necessary for a correct size shop head are being installed.
c. To assure that the hammering pressure caused during the rivet operation does not work-harden the repair parts.
d. To reduce the possibility of the repair parts shifting during the riveting operation and misaligning fastener holes.

72. (436) In a work situation involving the replacement of a skin panel, you should start the riveting process at

a. one side of the skin panel working toward the other side.
b. the top of the skin working toward the bottom.
c. the center working toward the top, then the bottom.
d. the center working alternately from side to side and from top to bottom.

73. (437) If MEK solvent is not available, which of the following may be used to clean seams which are to be sealed with aerodynamic smoothing compound?

a. Sanding.
b. Rotary filing.
c. Distilled water.
d. Aliphatic naphtha.

74. (437) The method used to remove excess cured aerodynamic smoothing compound from seams depends on the

a. hardness of the material sealed.
b. hardness of the compound surface.
c. amount of heat used to cure the compound.
d. temperature and relative humidity at the time the compound was applied.

75. (438) Of all the factors to consider when inspecting completed repairs, which single factor requires your closest attention?

a. Strength requirements.
b. Weight limitations.
c. Contour factor.
d. Corrosion prevention.

76. (438) When comparing a completed repair to technical order specifications, what additional factor normally not listed in TO specifications should be considered?

a. Scale.
b. Workmanship.
c. Tolerances.
d. Fastener requirements.

77. (438) The diameter and thickness of the nugget formed by spotwelding depends largely on the

a. location being welded.
b. thickness of the electrodes.
c. thickness of the metal being welded.
d. the metal being welded and the electrodes.

78. (439) The prime objective of spotwelding is to produce a joint

a. quicker and easier than standard fastening procedures.
b. that is flush on both sides requiring no surface preparation.
c. without additional material being added to the joint area.
d. without the loss of strength.

79. (440) The skin cutout required in a major spotweld repair is accomplished by using

a. chain drilling procedures.
b. a hole cutter.
c. a bottom reamer.
d. a counterbore.

80. (441) "Wet wing" aircraft refers to aircraft that have

a. an exterior skin of specially milled aluminum.
b. internal fuel tanks in the wings.
c. wings constructed with grooves between the milled and regular skin.
d. wings constructed with both dam and grooves.

81. (441) The number of areas where leaks could develop on an external fuel tank are reduced by

a. welding skin panels where possible.
b. using overlapping skin panels.
c. fabricating one-piece metal fuel tank.
d. sealing all seams with a metal bonding adhesive sealant.

82. (442) When power tools are needed in the repair of an internal fuel tank, they should be

a. air-driven.
b. explosion-proof.
c. sealed to reduce static electricity.
d. electrical with all connections made outside the fuel tank.

83. (443) If a dent on the skin surface of an internal fuel tank exceeds TO specifications, the damage is

a. negligible.
b. repairable by replacement.
c. repairable by smoothing compound.
d. repairable by patching.

84. (444) In making a damage area cutout on an external fuel tank for a welded flush repair, the cutout area must

a. have chamferred edges.
b. be circular in shape.
c. be cut oversize to allow for the weld.
d. have corner radii equal to the width of weld to be installed.

85. (444) After reshaping a dented area on the surface of an external fuel tank, cracks are found within the dented area. What most likely caused the cracks?

a. The corner radii were not large enough.
b. The dented area was not pre-heated prior to reshaping.
c. Too small a forming dolly was used during the reshaping.
d. The dented area became work-hardened during the hammering process.

86. (445) Which statement is not true concerning the fabrication of repair parts for fuel tank repairs?

a. A filler plate must be the same thickness as the original skin.
b. Reinforcement plates must be one gage thicker than the original skin.
c. Material composition of the repair parts must be of a temper condition stronger than the original temper condition.
d. Repair parts must be the same material composition, temper, and contour as the part being repaired.

87. (445) When a welded flush skin repair is made to an external fuel tank,

a. corner radii are not required in the cutout area.
b. reinforcement plates are normally not required.
c. all seams must be sealed using a fillet seal.
d. the filler plate must be cut underside to allow for expansion during the welding operations.

88. (446) Why are the fastener holes used in making a repair to a fuel tank very critical when solid rivets are not used?

a. The shank of non-rivet fasteners do not swell during installation.
b. Solid rivets can be sealed filling in the oversized holes.
c. Oversized fastener holes for non-rivet fasteners require additional torque, thus increasing the sealant requirements.
d. Oversized fastener holes for non-rivet fasteners allow the sealant to penetrate into the fastener hole thus causing corrosion.

89. (446) Close tolerance fastener holes are obtained in fuel tank repair parts by all of the following except

a. step-drilling.
b. chain-drilling.
c. pilot-drilling.
d. reaming procedures.

90. (447) Which of the following would be in the absolute seal classification?

a. Cabin area.
b. Liquid fuel.
c. Fuel vapor.
d. Weather.

91. (447) What classification of sealing is required for aerodynamic sealing of an aircraft wing?

a. Limited.
b. Intermediate.
c. Extensive.
d. Absolute.

92. (448) A bead of sealant applied along structural junctions or seams is which type of seal?

a. Fillet.
b. Faying.
c. Injection.
d. Gap.

93. (448) What type of seal is produced by the sandwiching of sealant between mating surfaces?

a. Faying.
b. Fillet.
c. Injection.
d. Contact.

94. (449) Sealant defects within a pressurized area can be detected by

a. checking the adhesion of seals by removing small sections of the seal.
b. performing a tack-free test while the area is pressurized.
c. passing a listening device along the seams while the area is pressurized.
d. applying a water-soap mixture to all seams and joints while the area is pressurized.

95. (449) When fabricating a sealant removal tool, the material should be

a. a soft plastic which will not scratch the surface.
b. aluminum alloy only.
c. made from hardwood with metal as an alternate.
d. the same material composition as the material sealed to reduce the possibility of corrosion.

96. (450) At what point in the cleaning of a surface for the application of a sealant is the cleaning operation completed?

a. When the cleaner dries upon contacting the surface.
b. Only after the surface being cleaned meets tack-free requirements.
c. When no discoloration is picked up by a finger touching the area.
d. When there is no discoloration on a clean drying cloth.

97. (451) If the normal storage life of a sealant is 6 months, how many months can the storage life be extended if the sealant meets the tack-free test requirement?

a. 1.
b. 2.
c. 3.
d. 4.

98. (451) If a one-part sealant does not go on smoothly, easily, and evenly, you should

a. throw it away.
b. add thinner.
c. add more accelerators.
d. whip air into the sealant.

99. (452) If TO directions call for a permanent type of seal between two parts, which type of seal should you install?

a. Fillet.
b. Injection.
c. Close tolerance.
d. Faying surface.

100. (452) What is the most efficient seal used on aircrafts?

a. Fillet.
b. Faying surface.
c. Injection.
d. Absolute.

101. (453) Sealants which have a long worklife normally have a

a. short curing period.
b. long curing period.
c. curing temperature above 120° F.
d. 3 percent addition of deionized water.

102. (453) Sealant with isopropyl alcohol added should <u>not</u> be used where

a. fuel fumes are present.
b. pressurization is required.
c. acrylic plastics are installed.
d. MEK has been used to clean the surface.

103. (454) Which of the following statements is not true regarding the safety precautions to observe when handling hazardous materials?

a. Always add water to acid.
b. Avoid prolonged breathing of solvents and acid vapors.
c. Do not eat or keep food in areas where it may absorb poisons.
d. When mixing alkalies with water, use containers which are made to withstand heat generated during the mixing.

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AIRFRAME REPAIR SPECIALIST

(AFSC 53153)

Volume 4

Fastening Methods

Extension Course Institute

Air University

606

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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

IN THE PREVIOUS volume, the only fastening method discussed in detail was solid shank rivets. This volume contains information pertaining to other fastening methods you use from day-to-day in accomplishing structural repairs. The first chapter discusses the various types of blind rivets. Different types of rivets, installation and removal tools, and inspection criteria are some of the areas covered. The second chapter is directed towards the fasteners needed in areas of high-strength requirements. Fasteners such as lock bolts, Hi-Lok, Jo-Bolts, and Hi-Shear rivets are just a few of the ones that are included in this chapter. The third chapter points out the individual features of the different types of turnlock fasteners used in today's aircraft. The last chapter is devoted to common and special hardware found in all aircraft—nuts, bolts, washers, and screws.

Code numbers appearing on figures are for preparing agency identification only.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to Tech Tng Cen/TTOXC, Chanute AFB IL 61868. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

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This volume is valued at 27 hours (9 points).

Material in this volume is technically accurate, adequate, and current as of July 1976.

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NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Blind Rivets

THERE ARE MANY places on the aircraft where access to both sides of the riveted structure or structural part is impossible. There are many places where the space is so limited that a bucking bar cannot be used. Also in the attachment of many nonstructural parts, such as aircraft interior furnishings, floorings, and the like, the full strength of solid shank rivets is not necessary. For use in such places, special rivets have been designed.

These special rivets are sometimes lighter than solid shank rivets, but they are strong enough for the intended use. These rivets are manufactured by several corporation and have characteristics that require special installation tools, special installation procedures, and special removal procedures. Since these rivets are usually inserted in places where one head (generally the shop head) cannot be seen, they are often called blind rivets. There are three types of mechanically expanded rivets: (1) self-plugging (friction lock) rivets, (2) self-plugging (mechanical lock) rivets, and (3) pull-thru rivets.

1-1. Friction Lock Blind Rivets

Self-plugging blind rivets are specifically designed to be used in place of solid shank rivets in blind or very limited access areas of an aircraft. An important reason that self-plugging blind rivets are used in maintenance repair is that time and costs can be drastically reduced where repairs can be made from one side of an assembly. This eliminates an expensive tear-down of an assembly to make both sides of an assemble accessible.

Although the self-plugging (friction lock) blind rivets are manufactured by several companies, the same general basic information about their construction features, material composition, and use applies to all of them.

600. State characteristic features of self-plugging (friction lock) blind rivets.

Construction Features. Self-plugging (friction lock) blind rivets are manufactured in two parts: (1) a hollow shank or sleeve, and (2) a stem that extend through the hollow shank. The stem of the self-plugging (friction lock) rivets consists of three parts: a serrated section, a play section, and an upsetting head, as shown in figure 1-1.

Several operations, in their proper sequence, happen when a pulling force is applied to the stem of the rivet: (1) the stem is pulled into the rivet shank, (2) the plug section of the stem forces the rivet shank to expand, and (3) the friction (or pulling action pressure) becomes great enough to cause the stem to snap at a break-off groove on the stem. The plug portion (bottom end of the stem) is retained in the shank of the rivet. The plug in the rivet gives the rivet a greater shear strength than could be derived from a hollow rivet.

Self-plugging (friction lock) rivets are fabricated in two common head styles: a protruding head similar to the universal head, and a 100° head, as shown in figure 1-2. Other head styles are available from some manufacturers.

Material Composition. Self-plugging (friction lock) blind rivets are fabricated from several materials. Rivets are available in the following material combinations: stem 2117 aluminum alloy and sleeve 2117 aluminum alloy; stem 2017 aluminum alloy and sleeve 5056 aluminum alloy; and a stem and sleeve of steel.

To help identify the material composition, the 5056 aluminum alloy sleeve is colored orange. Neither the 2117 aluminum alloy rivet nor the steel rivets are colored, but the weight and color of the metal itself separate these two rivets enough for easy identification.

Selection Factors. The factors you must consider in the selection of the correct self-plugging (friction lock) blind rivets are similar to those used for selecting correct solid shank rivets. The size of the rivet required and the area of the aircraft where you are going to install the rivet will directly influence your selection.

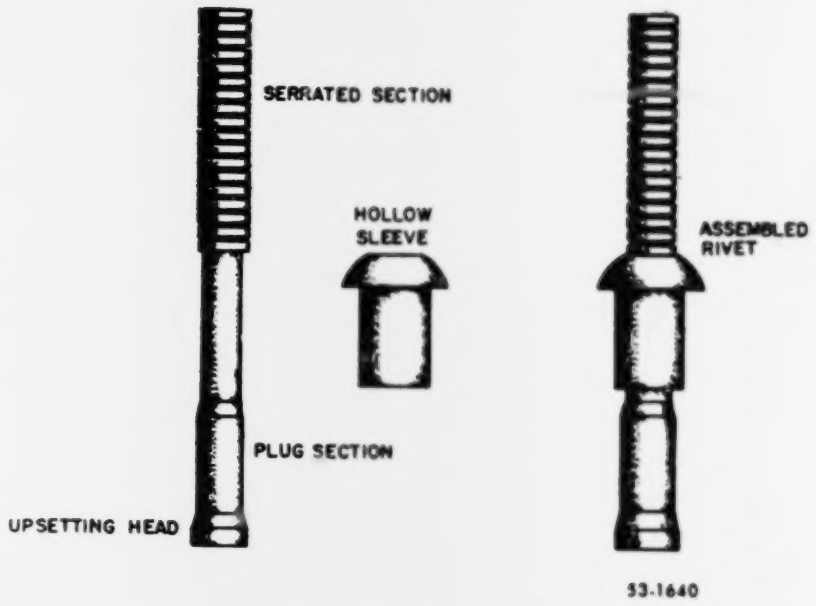


Figure 1-1. Friction lock blind rivet parts breakdown.

Determining rivet size. Self-plugging (friction lock) blind rivets are available in a variety of sizes. These sizes are identified by "grip length" and the diameter of the sleeve. Grip length is a term which indicates the total thickness of two or more pieces of metal that a rivet can fasten together properly. The sleeve of a self-plugging (friction lock) blind rivet is always longer than the indicated grip length. The extra length is what spreads and locks the rivet into place when the stem is pulled through the sleeve. As a rule, the sleeve of the rivet should be approximately 3/64th of an inch to 1/8th of an inch longer than the metal thickness as shown in figure 1-3.

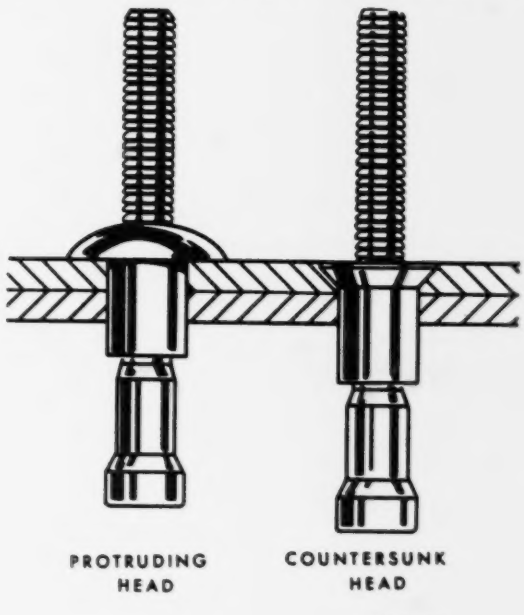


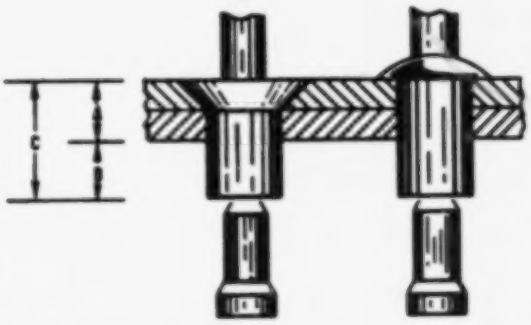
Figure 1-2. Friction lock blind rivet head styles.

Grip lengths of self-plugging (friction lock) blind rivets are manufactured in graduations of 1/16th of an inch (3/16, 4/16, 5/16, etc.). Diameters are manufactured in graduations of 1/32 of an inch (4/32, 5/32, 6/32, etc.). Normal diameter size range is from 3/32 to 8/32 of an inch. Oversized diameter rivets are available for replacement tasks where a rivet hole is worn. If the proper rivet size is loose in the hole, and the next size larger rivet will not fit, you would use one of these oversized rivets. Oversized rivets are 1/64th of an inch larger than ordinary rivets and are identified by a blue colored sleeve.

Each company that manufactures self-plugging (friction lock) rivets has a code number to help users obtain the correct rivet for the grip range or material thickness of a particular installation. In addition, the Air Force also has military standard (MS) numbers for identification purposes. The examples of part numbers for self-plugging (friction lock) rivets, illustrated in figure 1-4, are only a sample of each.

NOTE: Notice in the examples in figure 1-4 that each part number has a portion designated as the grip range. This is the thickness of material that can be satisfactorily joined together with that rivet. As a general rule, this can be exceeded (plus or minus) by 1/64 inch.

Areas of applications. Self-plugging (friction lock) blind rivets are *not* to be used on control surface hinge brackets, wing attachment fittings, or in other similar heavily stressed locations. These rivets also are *not* to



A — THICKNESS OF MATERIAL (GRIP RANGE)
B — 3/64 TO 1/8 INCH
C — TOTAL RIVET SHANK LENGTH

53-1645

Figure 1-3. Friction lock blind rivet grip range.

be used where a fluid-tight joint is required. Self-plugging (friction lock) blind rivets should not be used to replace solid shank rivets unless *absolutely* necessary and allowed by technical order specifications. In cases where it is necessary to replace a solid shank rivet with a self-plugging (friction lock) blind rivet, you may replace 2117-T4 solid shank rivets, size for size. When used to replace 2017-T31 solid rivets, the next size self-plugging (friction lock) blind rivet must be used. When replacing solid shank rivets, you must check the size of the hole. If the hole diameter, after removal of the solid shank rivet, exceeds the maximum allowable hole size, the next larger size self-plugging (friction lock) blind rivet should be used. Self-plugging (friction lock) blind rivets should not be used in a given joint to replace such a considerable number of solid rivets that overstressing of the remaining solid rivets may result. Also self-plugging (friction lock) blind rivets are not used to replace self-plugging (mechanical lock) blind rivets because of the loss of the shear strength that would result, as shown in table 1-1.

If the rivet is to be installed on an aerodynamically smooth surface, or clearance for an assembly is needed, countersunk-head rivets are selected. In other areas where clearance or smoothness is not a factor, the universal head type rivets are used.

Material composition of the rivet shank will depend upon the type of material being riveted. Aluminum alloy 2117 shank rivets are used on most aluminum alloys. Aluminum alloy 5056 shank rivets are used when the material being riveted is magnesium. Steel rivets are always selected for riveting assemblies fabricated from steel.

Since a hammering force is not necessary to install self-plugging (friction lock) rivets, they can be used to attach materials such as plywood or plastic to metal structures. They can also be used to attach assemblies to hollow tubes, corrugated sheet, hollow boxes, etc. When in doubt about whether to install a self-plugging (friction lock) blind rivet or not, consult the specific technical order for the aircraft being repaired.

Exercises (600):

1. Why is it important that the plug section of the stem used in self-plugging (friction lock) blind rivets be retained in the hollow sleeve?

2. Self-plugging (friction lock) blind rivets which have an orange colored sleeve are used in what type of material?

3. Besides their material color, how are aluminum self-plugging (friction lock) blind rivets identified from steel self-plugging (friction lock) blind rivets?

4. Why is the sleeve of self-plugging (friction lock) blind rivets always longer than the required grip length?

5. If the material being riveted is 1/8th of an inch thick, what is the longest rivet that should be used?

6. What fractional measurement is used to denote the diameter of self-plugging (friction lock) blind rivets?

7. How are oversized self-plugging (friction lock) blind rivets identified?

8. When are self-plugging (friction lock) blind rivets used to replace solid shank rivets?

9. Why is it recommended that self-plugging (friction lock) blind rivets *not* be used to replace self-plugging (mechanical lock) blind rivet?

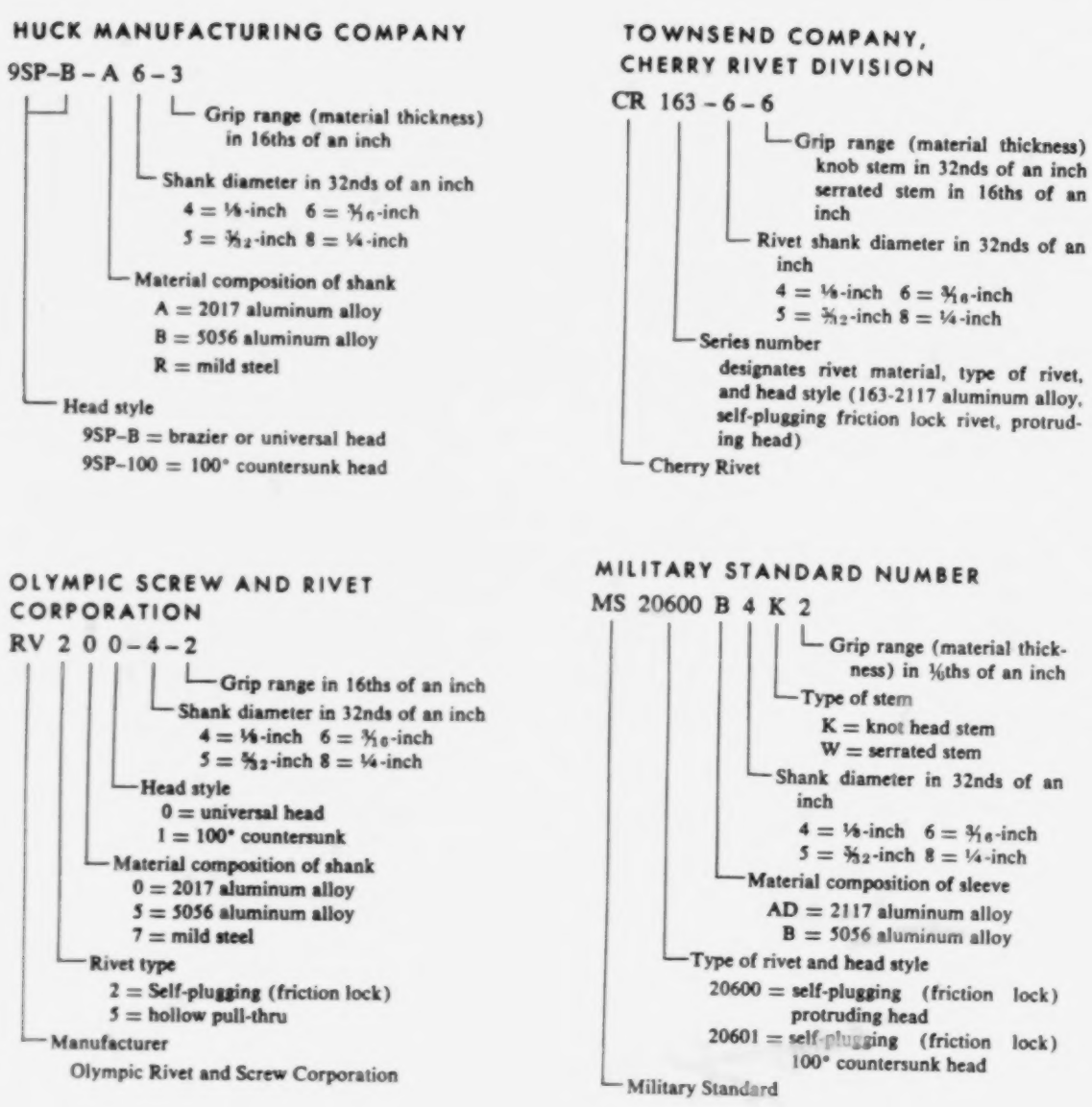

HUCK MANUFACTURING COMPANY
9SP–B – A 6 – 3
Grip range (material thickness) in 16ths of an inch
Shank diameter in 32nds of an inch
4 = ⅛-inch 6 = 3/16-inch
5 = 5/32-inch 8 = ¼-inch
Material composition of shank
A = 2017 aluminum alloy
B = 5056 aluminum alloy
R = mild steel
Head style
9SP–B = brazier or universal head
9SP–100 = 100° countersunk head
TOWNSEND COMPANY, CHERRY RIVET DIVISION
CR 163 – 6 – 6
Grip range (material thickness) knob stem in 32nds of an inch serrated stem in 16ths of an inch
Rivet shank diameter in 32nds of an inch
4 = ⅛-inch 6 = 3/16-inch
5 = 5/32-inch 8 = ¼-inch
Series number
designates rivet material, type of rivet, and head style (163-2117 aluminum alloy, self-plugging friction lock rivet, protruding head)
Cherry Rivet
OLYMPIC SCREW AND RIVET CORPORATION
RV 2 0 0 – 4 – 2
Grip range in 16ths of an inch
Shank diameter in 32nds of an inch
4 = ⅛-inch 6 = 3/16-inch
5 = 5/32-inch 8 = ¼-inch
Head style
0 = universal head
1 = 100° countersunk
Material composition of shank
0 = 2017 aluminum alloy
5 = 5056 aluminum alloy
7 = mild steel
Rivet type
2 = Self-plugging (friction lock)
5 = hollow pull-thru
Manufacturer
Olympic Rivet and Screw Corporation
MILITARY STANDARD NUMBER
MS 20600 B 4 K 2
Grip range (material thickness) in 1/16ths of an inch
Type of stem
K = knot head stem
W = serrated stem
Shank diameter in 32nds of an inch
4 = ⅛-inch 6 = 3/16-inch
5 = 5/32-inch 8 = ¼-inch
Material composition of sleeve
AD = 2117 aluminum alloy
B = 5056 aluminum alloy
Type of rivet and head style
20600 = self-plugging (friction lock) protruding head
20601 = self-plugging (friction lock) 100° countersunk head
Military Standard
53-1649

Figure 1-4. Friction lock blind rivet part numbers.

10. When self-plugging (friction lock) blind rivets are used to replace 2017-T31 solid rivets, what is the rule to follow?

601. Point out pertinent requirements relating to the installation and removal of self-plugging (friction lock) blind rivets.

Installation Tools. The tools that you use to install self-plugging (friction lock) blind rivets depend upon the manufacturer of the rivet that is being installed. Each company has special tools which are used to insure satisfactory results with their product. Hand tools as well as pneumatic tools are available.

Figure 1-5, illustrates some of the installation tools used to install self-plugging (friction lock) blind rivets. Nomenclature for the various tools and assemblies available depends upon the manufacturer. Application and use of the equipment is basically the same. Whether called a hand tool, air tool, hand gun, or penumatic gun, all of these are used with but one goal—the proper installation of a rivet.

TABLE 1-1
BLIND RIVETS SHEAR STRENGTHS

RIVET DIAMETER	RIVET HOLE DIAMETER	SHEAR STRENGTH		
		ALUM	MONEL	A286
1/8	.129/.132	495	1020	1090
5/32	.160/.164	755	1565	1670
3/16	.192/.196	1090	2260	2400
1/4	.256/.261	1970	4000	4250

SINGLE SHEAR STRENGTH-FRICTION LOCK RIVET
(ALUMINUM)

RIVET DIAMETER	RIVET HOLE DIAMETER	SHEET THICKNESS	SHEAR STRENGTH IN POUNDS
1/8	.129	.040	387
5/32	.160	.050	598
3/16	.192	.064	858
7/32	.220	.072	1152
1/4	.257	.081	1556

53-1654

SINGLE SHEAR STRENGTH-MECHANICAL LOCK RIVET

The portion of the tool or gun that is of prime importance to you is the part that is placed on the rivet. Whether it is called a nose assembly or sleeve and drawbolt, always assure yourself that you selected the size that is the same as the rivet shank diameter. For ease of selection, the sizes are stamped on the parts of the nose assembly.

Pneumatic tools operate on the same air pressure as pneumatic riveting hammers, 90 to 100 psi. Follow the operational procedures and adjustments recommended by the manufacturer.

Installation Procedures. (See fig. 1-6.) After selection or determination of the rivet to be used in any installation, determine the proper size twist drill. Generally, manufacturers recommend the following finish drill sizes for the common shank diameters:

-4	#30 drill	-6	#10 drill
-5	#20 drill	-8	F drill

Exercise care when drilling the material. Hold the drill at right angles to the work at all times to keep from drilling an elongated hole. The self-plugging (friction lock) rivet will not expand as much as a solid shank rivet. If the hole is too large or elongated, the shank will not properly fill the drilled hole. Common hand or pneumatic powered drills available to airframe personnel are used to drill the holes. Hole clearance of 0.002 to 0.004 is required when installing self-plugging (friction lock) rivets.

After the hole is drilled and countersunk (if required), select the proper nose assembly and installation gun. It is important that the proper nose assembly be used for the rivet being installed. The nose assembly should correspond to the diameter and head style of the rivet. Speed of installation may be increased by inserting a number of rivets in the work and then applying the gun. In other instances, such as overhead work, it is apparent that this method would be impractical and the rivet should be loaded into the prepared hole. The rivet must be completely inserted into the slot in the nose assembly, because improper seating of the rivet may permit the head to break off before the rivet is properly set. When using a hand gun, hold the rigid handle of the gun parallel to the rivet axis. Open the movable handle as far as it will go, then partially close. Repeat this operation until the rivet stem breaks, then release the gun by completely closing the movable handle.

When using the power gun, hold the head of the gun parallel to the axis of the rivet. Push the gun against the work with enough force to seat the head of the rivet firmly, and to insure contact between the parts being riveted. Pull the trigger until the stem breaks. The stem will be ejected through the rubber tube at the

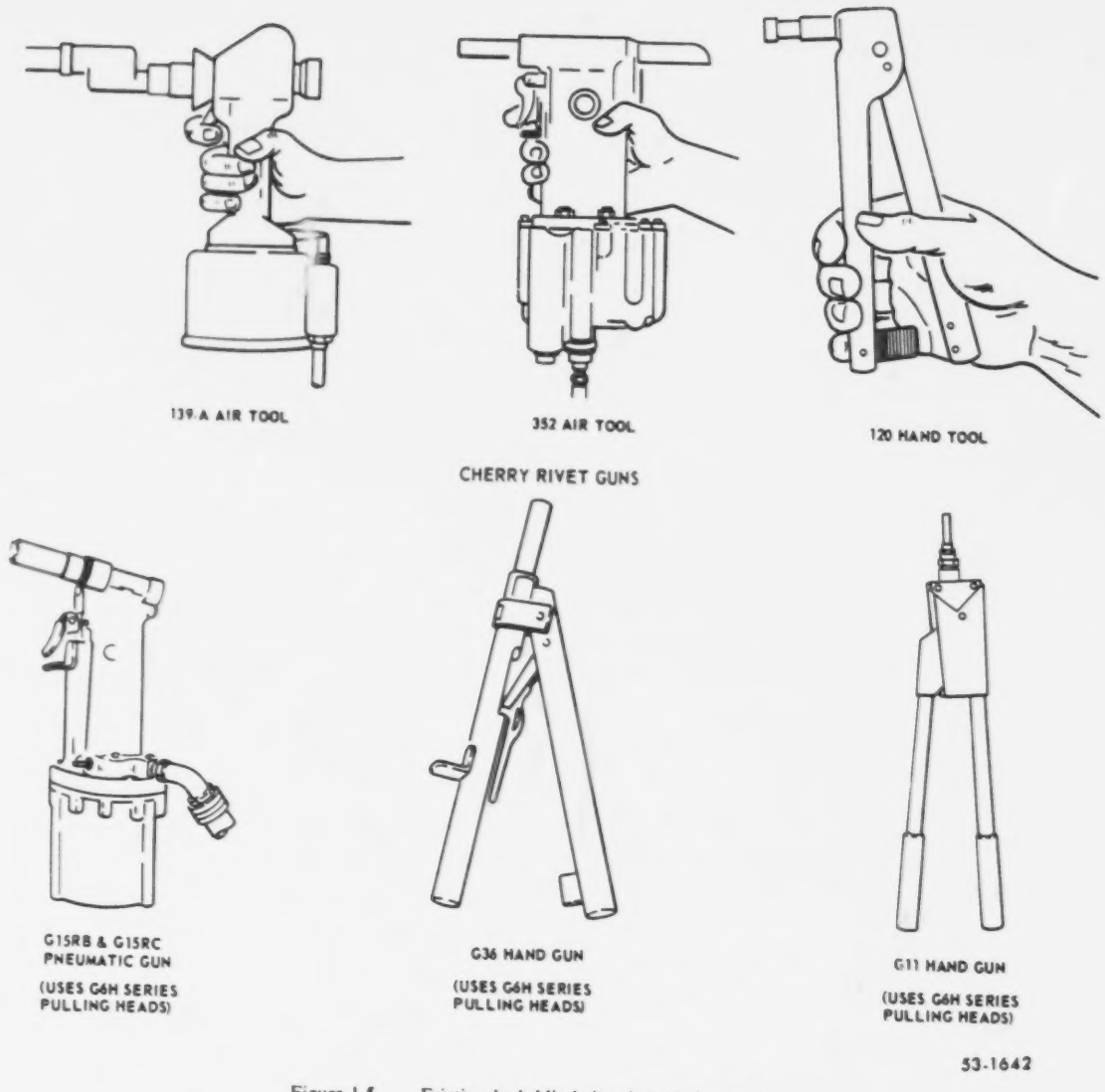


Figure 1-5. Friction lock blind rivet installation tools.

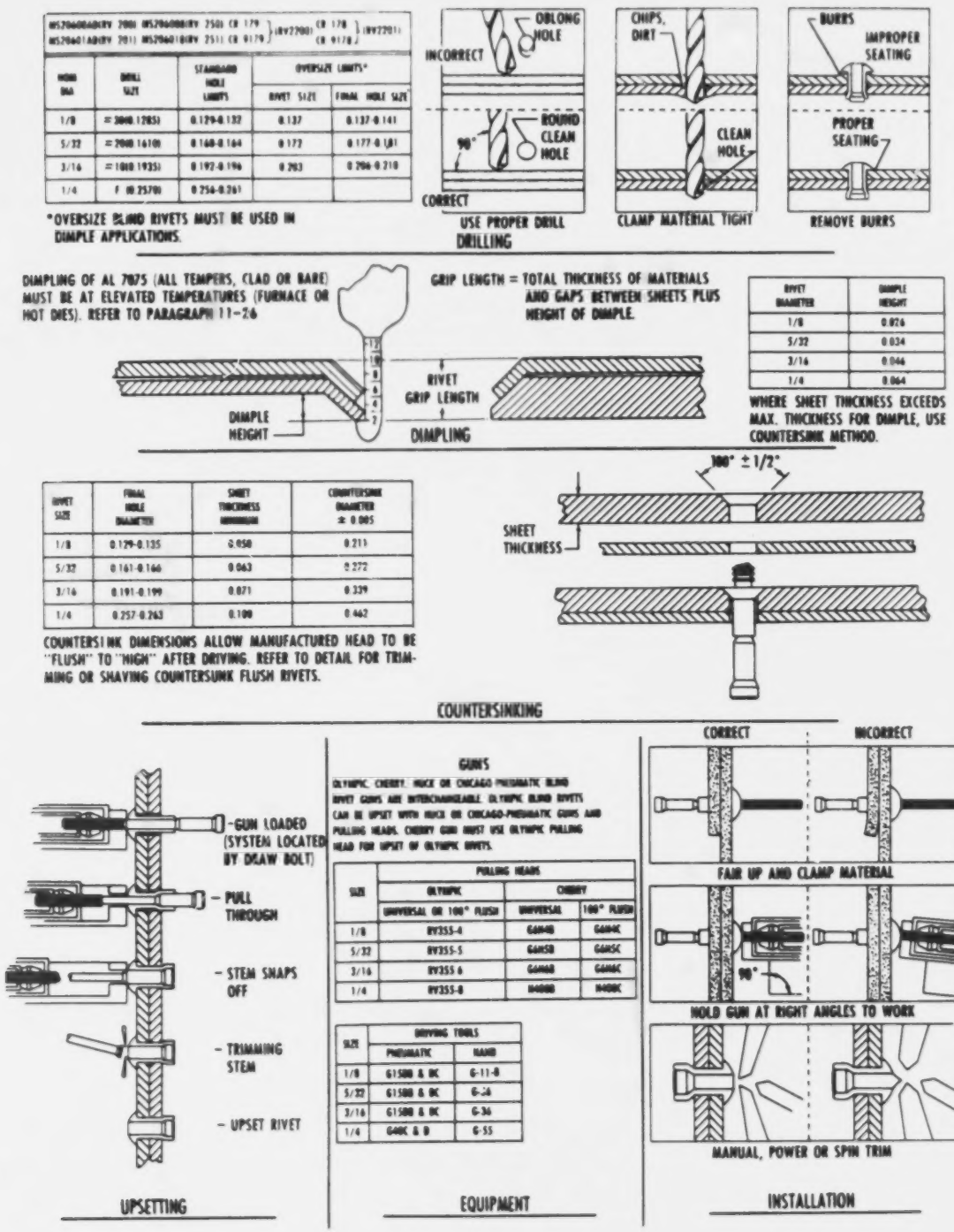
back of the gun head. It is important that this tube be in place in order to prevent stems from getting into the gun mechanisms. Figure 1-6 illustrates sequence of operation during the installation process.

After installation of the self-plugging (friction lock) blind rivet, trim the stem flush with the rivet head. Use a pair of diagonal pliers ground smooth on the cutting side. Press the pliers down tight against the rivet head to cut the stem as close to the head as possible. Use a flat file to further smooth the stem, but be careful not to file into the head itself. Stem trimmers and stem saws are available to trim the stem. If aerodynamic smoothness is a factor, the stem can be shaved with a rivet shaver. Again be careful that you do not cut into the head proper.

Removal Procedures. Self-plugging (friction lock) rivets are removed in the same manner as solid shank rivets except for the preliminary step of driving out the stem, illustrated in figure 1-7. Use the following steps in their proper sequence:

- Punch out the rivet stem with a pin punch.
- Drill out the rivet head, using a drill the same size as the rivet shank.
- Pry off the weakened rivet head with a pin punch.
- Push out the remainder of the rivet shank with a punch. If the shank will not push out, drill the shank, taking care not to enlarge the hole in the material.

CAUTION: When drilling out blind rivets, you should make a reasonable effort to remove the blind end of the rivet which was punched into the structure. If you cannot remove the blind end, make an effort to remove as many pieces as possible.


USE PROPER DRILL DRILLING
CLAMP MATERIAL TIGHT
REMOVE BURRS
*OVERSIZE BLIND RIVETS MUST BE USED IN DIMPLE APPLICATIONS.
DIMPLING OF AL 7075 (ALL TEMPERS, CLAD OR BARE) MUST BE AT ELEVATED TEMPERATURES (FURNACE OR HOT DIES). REFER TO PARAGRAPH 11-26
GRIP LENGTH = TOTAL THICKNESS OF MATERIALS AND GAPS BETWEEN SHEETS PLUS HEIGHT OF DIMPLE.
DIMPLE HEIGHT
RIVET GRIP LENGTH
DIMPLING
WHERE SHEET THICKNESS EXCEEDS MAX. THICKNESS FOR DIMPLE, USE COUNTERSINK METHOD.
100° ± 1/2°
SHEET THICKNESS
COUNTERSINKING
COUNTERSINK DIMENSIONS ALLOW MANUFACTURED HEAD TO BE "FLUSH" TO "HIGH" AFTER DRIVING. REFER TO DETAIL FOR TRIMMING OR SHAVING COUNTERSUNK FLUSH RIVETS.
GUN LOADED (SYSTEM LOCATED BY DRAW BOLT)
PULL THROUGH
STEM SNAPS OFF
TRIMMING STEM
UPSET RIVET
UPSETTING
GUNS
EQUIPMENT
CORRECT
INCORRECT
FAIR UP AND CLAMP MATERIAL
HOLD GUN AT RIGHT ANGLES TO WORK
MANUAL, POWER OR SPIN TRIM
INSTALLATION
53-1656

RIVET DIAMETER	DIMPLE HEIGHT
1/8	0.026
5/32	0.034
3/16	0.044
1/4	0.064

RIVET SIZE	FINAL HOLE DIAMETER	SHEET THICKNESS MINIMUM	COUNTERSINK DIAMETER ± 0.005
1/8	0.129-0.135	0.050	0.211
5/32	0.161-0.166	0.063	0.272
3/16	0.191-0.199	0.071	0.339
1/4	0.257-0.263	0.100	0.462

SIZE	PULLING HEADS			
	OLYMPIC		CHERRY	
	UNIVERSAL OR 100° FLUSH		UNIVERSAL	100° FLUSH
1/8	BY355-4		G604B	G604C
5/32	BY355-5		G605B	G605C
3/16	BY355-6		G606B	G606C
1/4	BY355-8		H608B	H608C

SIZE	DRIVING TOOLS	
	PNEUMATIC	HAND
1/8	G1500 & BC	G-11-8
5/32	G1500 & BC	G-24
3/16	G1500 & BC	G-36
1/4	G40C & B	G-55

Figure 1-6. Friction lock blind rivet installation data.

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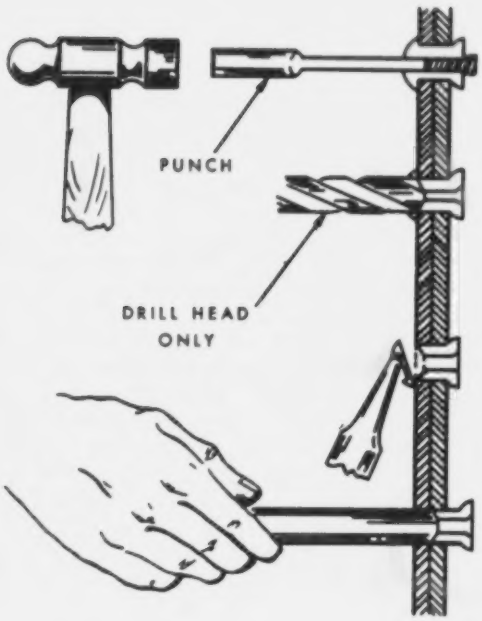


Figure 1-7. Friction lock blind rivet removal sequence.

Exercises (601):

1. How much air pressure is needed to operate pneumatic installation tools used for self-plugging (friction lock) blind rivets?

2. What is the hole clearance required for self-plugging (friction lock) blind rivets?

3. What size twist drill is required to drill holes for installing RV200-5-2 self-plugging (friction lock) blind rivets?

4. The nose assembly used to install self-plugging (friction lock) blind rivets should correspond to what physical feature of the rivet being installed?

5. What size twist drill is used to remove self-plugging (friction lock) blind rivets?

602. Cite specific details of the inspection criteria used when inspecting installed self-plugging (friction lock) blind rivets.

The inspection of installed self-plugging (friction lock) blind rivets is often limited to the manufacturer head. If you can see the shop head side of the installed rivet, inspect it for the requirements illustrated in figure 1-8. When the shop head is classified as unsatisfactory, remove the rivet and install another in its place. When inspecting the manufacturer head, you should observe surface contact and stem retention.

Surface Contact Criteria. Countersunk rivets must meet the aerodynamic smoothness requirements for the area where they are installed. Allowable gaps between the head of the rivet and the surface of the hole are very limited and are usually spelled out in the specific -3 TO. Normally, a gap between the head of the rivet and the surface must not exceed 0.002 of an inch provided that 60 percent of the rivet head is bearing against the surface of the hole.

Gaps under the head of protruding head rivets are allowable, provided they meet TO specifications when measured at the rivet shank and the rivet head is in contact with the surface. The amount of gap allowed will depend on the diameter of the rivet. Gaps between faying surfaces of the parts riveted together must *not* exceed 5 percent of the thickness of the thinnest part when measured at the shank of the rivet.

Stem Retention Factors. You can test self-plugging (friction lock) blind rivets by applying force to the rivet stem. Table 1-2, points out the different pressure requirement for each diameter rivet. If the rivets have been correctly installed, especially in regards to grip length and hole diameter, it is not considered necessary to perform this test. However, if you suspect an incorrect rivet installation, test it by applying the force shown in Table 1-2.

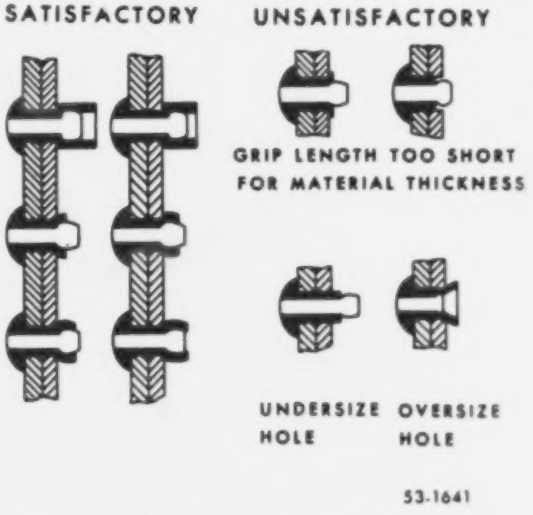


Figure 1-8. Friction lock blind rivet installation criteria.

TABLE 1-2
FRICTION LOCK BLIND RIVET PIN RETENTION PRESSURES

RIVET DIAMETER (INCH)	PIN FORCE (POUNDS)
1/8	15
5/32	25
3/16	35
1/4	50

53-1655

Exercises (602):

1. When is a 0.002 gap between the rivet head of a countersunk self-plugging (friction lock) blind rivet and the countersunk or dimpled hole allowed?

2. When measuring for gaps between the head of a universal type self-plugging (friction lock) blind rivet and the work surface, where should you take the measurement?

3. How is the gap allowance between parts riveted with (friction lock) blind rivets determined?

4. When is a stem retention pressure test required for installed self-plugging (friction lock) blind rivets?

5. What two factors, if closely followed, would eliminate the need for a stem retention pressure test for installed self-plugging (friction lock) blind rivets?

1-2. Mechanical Lock Blind Rivets

Self-plugging (mechanical lock) blind rivets are similar in many ways to self-plugging (friction lock) rivets, except for the manner in which the stem is retained in the sleeve.

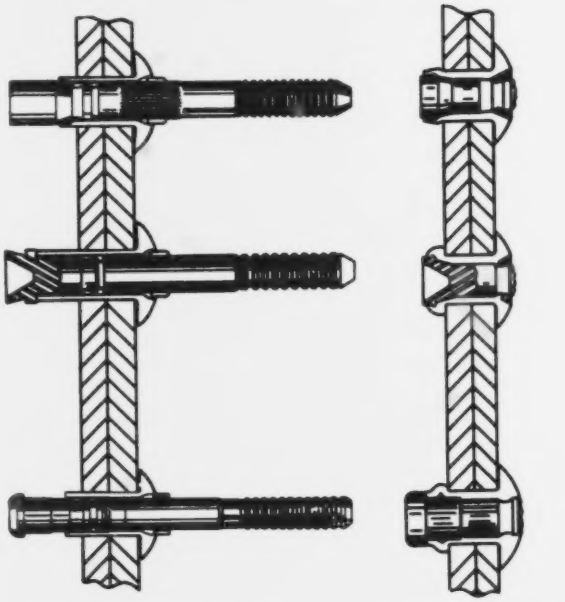
603. State the principle features of a self-plugging (mechanical lock) blind rivet.

Construction Features. The self-plugging (mechanical lock) blind rivet has a positive mechanical locking collar that resists vibration which would cause the self-plugging (friction lock) blind rivet stem to fall out. This collar is seated into the locking position during the installation of the rivet. Another feature of the self-plugging (mechanical lock) blind rivet is that the stem breaks off flush with the head, eliminating having to trim the stem.

Figure 1-9, shows two of the various styles of self-plugging (mechanical lock) blind rivets in use today. Because of the similarities of self-plugging (mechanical lock) blind rivets, our discussion will be centered primarily towards the Cherry-lock type. When areas are discussed that greatly differ between the various types of self-plugging (mechanical lock) blind rivets, this will be noted in the test.

Self-plugging (mechanical lock) blind rivets consist of three parts: a hollow sleeve (including a conical recess for the locking collar), a serrated stem that extends through the sleeve, and a separate locking collar. They are manufactured in two types—the standard and the bulbed type. The material composition of the individual parts will differ from type to type. Self-plugging (mechanical lock) blind rivets are manufactured in two head styles—100° countersunk and the universal head.

Standard type. The standard type self-plugging (mechanical lock) blind rivet, figure 1-10, has a serrated stem containing an enlarged (constant diameter) plug section. This type of stem produces a shop head similar to the self-plugging (friction lock) blind rivet, as shown in the upper right hand corner of figure 1-10. The rivet sleeve and stem are available in material compositions of aluminum, monel, corrosion resistant



53-1647

Figure 1-9. Types of mechanical lock blind rivets.

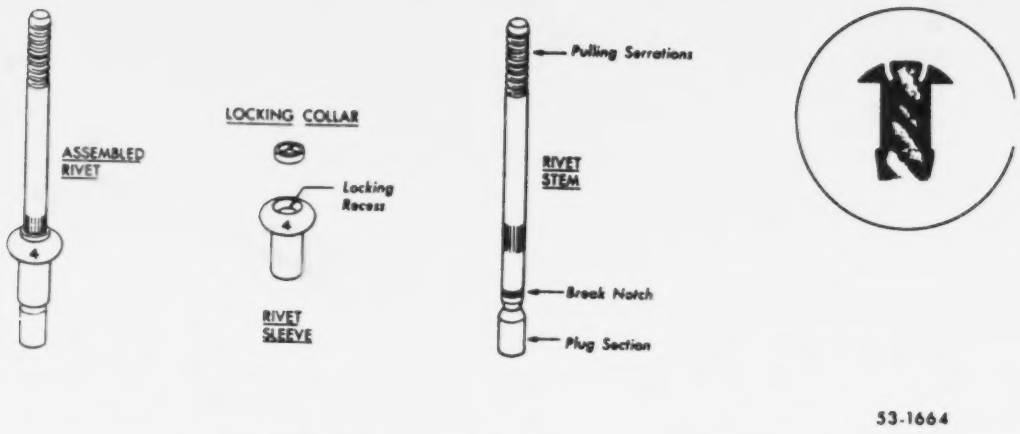


Figure 1-10. Standard type mechanical lock blind rivet (cherrylock).

steel, inconel, and titanium. The locking collar is available in similar material composition with the exception of titanium. Standard self-plugging (mechanical lock) blind rivets are used in countersunk materials, thick sheet applications, and sealing applications.

Bulbed type. The bulbed type self-plugging (mechanical lock) blind rivet showing in figure 1-11, has a serrated stem containing a machined variable diameter cone shaped section. This type of stem design produces a "bulbed"shaped shop head, as shown in the upper right hand corner of figure 1-11. This rivet sleeve is fabricated from aluminum, monel, and inconel. The stem and locking collars are fabricated from inconel, monel, and corrosion resistant steel. Bulbed self-plugging (mechanical lock) blind rivets are especially effective in this dimpled skin because they are 1/64 of an inch oversized in sleeve diameter. This overcomes the problem of elongations which occurs when dimpling a hole.

Selection Factors. Use the same general requirements in selecting self-plugging (friction lock) blind rivets that you use when selecting self-plugging (mechanical lock) blind rivets.

Installation location. If the rivet is to be located on an aerodynamically smooth surface, or clearance for an assembly is needed, select countersunk-head rivets. In other areas, where clearance or smoothness is not a factor, use the protruding head type rivets.

Material composition. The composition of the material being riveted together will determine the composition of the rivet sleeve. Rivet sleeves of 2017 aluminum alloy are used for most aluminum alloy applications. For magnesium alloys, a rivet sleeve of 5056 aluminum is required. Steel sleeved rivets are used in steel assemblies where high strength and high temperature resistance are required. Markings in the form of a letter or symbol, indicating the material composition of the rivet, are stamped on the head of the rivet. Briefly refer to figure 1-9 and notice the system used for the Cherrylock rivet. Aluminum sleeved rivets usually do not have a head marking.

Determining rivet size. As with all blind rivets, the correct grip length and proper diameter are critical

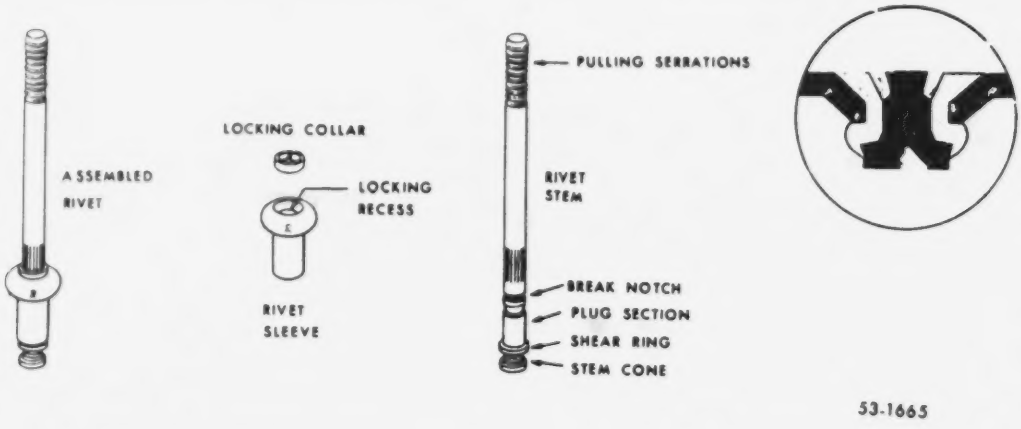


Figure 1-11. Bulbed type mechanical lock blind rivet (cherrylock).

factors when installing blind rivets. The grip length of self-plugging (mechanical lock) blind rivets refers to the maximum total thickness of the parts to be riveted together and is measured in 16ths of an inch. The maximum grip length is stamped on the heads of self-plugging (mechanical lock) blind rivets. In figure 1-12, note the number 4 on the rivet head. This number (4) refers to the maximum material thickness (1/4 of an inch) that can be successfully riveted using this rivet. The minimum grip length for self-plugging (mechanical lock) blind rivets is always 1/16th of an inch less than that indicated on the rivet head. In this case it would be 3/16th of an inch.

Diameters of self-plugging (mechanical lock) blind rivets are measured in increments of 32nds of an inch, as shown in figure 1-13. The standard self-plugging (mechanical lock) blind rivets are fabricated in diameters of 3/32, 4/32 (1/8), 5/32, 6/32 (3/16) and 8/32 (1/4) of an inch. The bulbed self-plugging (mechanical lock) blind rivets are fabricated in sleeve diameters 4/32 (1/8), 5/32, 6/32 (3/16) of an inch.

Application factors. The self-plugging (mechanical lock) blind rivets have all of the strength characteristics of a solid shank rivet. The loads allowable for the self-plugging (mechanical lock) blind rivets are comparable to those for solid shank rivets of the same shear strength, regardless of sheet thickness. The composite ultimate shear strength of the 5056-H14 shank and the 2024-T36 pin exceeds 38,000 psi on standard rivet hole diameter; their tensile strength is in excess of 28,000 psi. Pin retention characteristics are excellent in these rivets and the possibility of the pin working out is minimized by the lock formed in the rivet head. The mechanical lock feature increases the load-carrying capacity in single shear from about 10.3 percent in the case of thick sheets where joint strength is considered critical in rivet shear, to as much as 63.3 percent in thin sheets where sheet bearing is considered critical.

Self-plugging (mechanical lock) blind rivets may be used as replacement for self-plugging (friction lock) blind rivets on a one to one basis. It is recommended that a 1/64th inch oversized self-plugging (mechanical lock) blind rivet be used. A standard type self-plugging (mechanical lock) blind rivet should not be used to replace a bulbed type because of the differences in diameters. Always check the specific -3 technical order for the aircraft being repaired when installing self-plugging (mechanical lock) blind rivets.

CAUTION: Blind rivets, regardless of the type, should *not* be used in areas where it would be hazardous if the stem or locking collar were to fall out of the rivet, such as in an engine intake or an electronic area.

Exercises (603):

1. How does a self-plugging (mechanical lock) blind rivet differ from a friction lock blind rivet in construction?

2. Which installation step required when installing friction lock blind rivets is *not* necessary when installing self-plugging (mechanical lock) blind rivets?

3. Which type of self-plugging (mechanical lock) blind rivet produces a shop head similar to those produced by friction lock blind rivets?

4. What type of self-plugging (mechanical lock) blind fivet would you select to fasten thin dimpled sheets together?

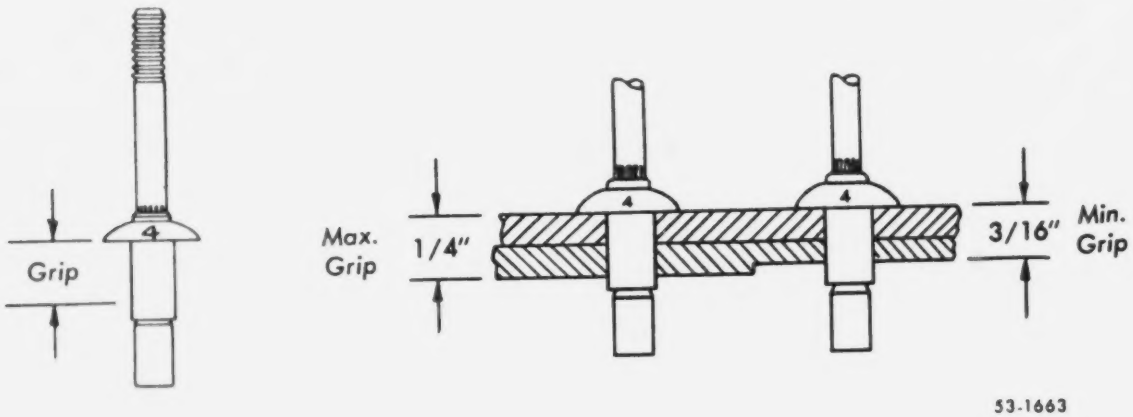


Figure 1-12. Mechanical lock blind rivet grip range.

5. What factor restricts the use of standard type self-plugging (mechanical lock) blind rivets from being used as a replacement for bulbed type self-plugging (mechanical lock) blind rivets?

6. How is the material composition of self-plugging (mechanical lock) blind rivets identified?

7. How do the fractional increments used to denote the grip range and diameter of self-plugging (mechanical lock) blind rivets compare to those used for self-plugging (friction lock) blind rivets?

8. What is indicated by the number stamped on the head of self-plugging (mechanical lock) blind rivewts?
ets?

9. How does the strength factors of self-plugging (mechanical lock) blind rivets compare to those of solid shank rivets?

10. Where is the use of self-plugging (mechanical lock) blind rivets *not* allowed?

604. Specify details of the working practices to employ when installing and removing self-plugging (mechanical lock) blind rivets.

Self-plugging (mechanical lock) blind rivets require special driving assemblies. For best results, use the tools manufactured by the company that produces the type rivet you are installing. The type of equipment available may be either hand or power operated. The choice you make will be influenced by several factors: the quantity of rivets to be installed, the availability of air supply, the accessability of the work area, and the size and type of rivets you are installing.

When you are selecting installation tools, it is very important that the correct *"pulling head"* be selected. Cherrylock rivets require a separate pulling head for each head style, whereas Olympic-Lok rivets require only one pulling head for both head styles. Information usually can be founded in the specific -3 TO for the proper matching of installation tools.

Shop Head Formation. To properly install self-plugging (mechanical lock) blind rivets, you should have an understanding of what takes place as the shop head is formed. Refer to figure 1-14, during the following description of the installation sequence:

Step 1. As the stem is drawn into the sleeve, the sleeve expands, filling in the hole clearance between the sleeve and the material.
Step 2. As a pulling force is exerted on the stem, the bottom of the stem is forced against the sleeve of the rivet. This causes the sleeve to bulge against the back side of the material in a bulbed type shop head. This secures the two pieces of material together.
Step 3. At a predetermined point an inner anvil in the nose assembly of the rivet gun advances automatically and drives the locking collar into the conical recess.
Step 4. Once the shop head is formed and the stem is locked in the rivet, the steam breaks off flush with the rivet head. The stem does not normally need to be trimmed.

Installation Procedures. Procedures used in installing self-plugging (mechanical lock) rivets are basically the same as those used for installing the self-plugging (friction lock) blind rivet. The important factors to be considered are rivet selection, hold preparation, and riveting technique.

Rivet selection. Make sure the correct grip range is selected. Too long or too short a grip range will cause the stem to break off improperly.

Hole preparation. Hole size and hold alignment are very critical. Undersized and misaligned holes will

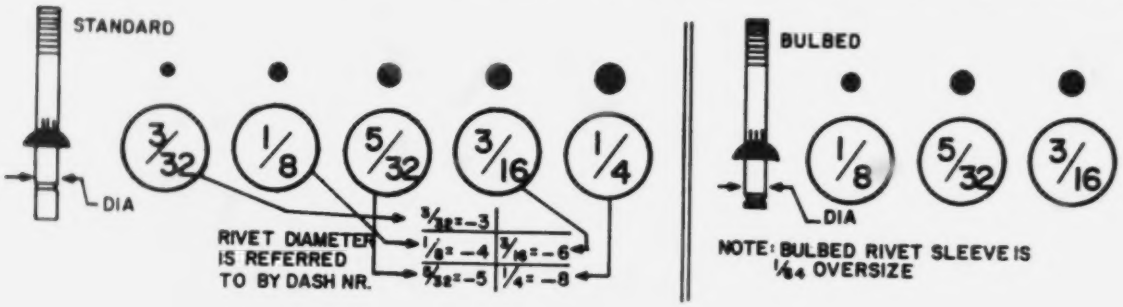


Figure 1-13. Mechanical lock blind rivet diameter measurements.

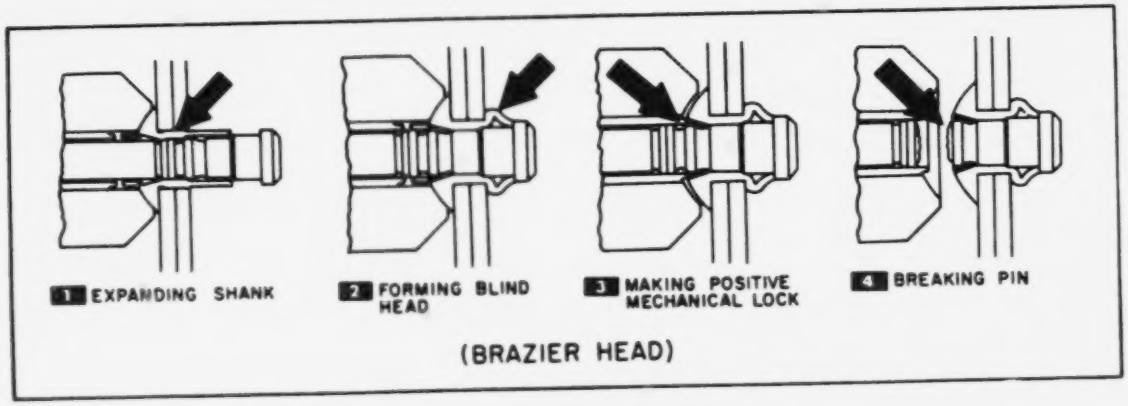


Figure 1-14. Mechanical lock blind rivet installation sequence.

cause the stem to break off prematurely; resulting in a defective rivet. Oversized and elongated holes will also result in a defective rivet. To insure proper hole alignment and to prevent burrs and/or chips from lodging between the sheets, the material to be drilled must be clamped tightly together. Before clamping the material, remove any foreign matter that may be lodged between the sheets.

For standard type, self-plugging (mechanical lock) blind rivets the correct size drills are:

Rivet Dia.	Drill Size	Hole Tolerances
-3	#40	.097—.101
-4	#30	.129—.132
-5	#20	.160—.164
-6	#10	.192—.196
-8	#F	.256—.261

For bulbed type, self-plugging (mechanical lock) blind rivets the correct size drills are:

Rivet Dia.	Drill Size	Hole Tolerances
-4	#27	.143—.146
-5	#16	.176—.180
-6	# 5	.205—.209
-8	# 1	.271—.275

Riveting technique. Always hold the rivet gun in line with the axis of the rivet being installed. Certain rivets require that the rivet gun be held firmly against the rivet head, while some require that the rivet gun be held in a light and flexible manner above the rivet head. The reason for this is that some nose adapters (Cherrylock rivets) have a built-in stop, which prevents the stem from being fully inserted into the nose adapter. Forcing the nose adapter down into the rivet head will cause the rivet assembly to come apart. The pulling head will be pulled down against the rivet head when the rivet gun is activated. Always follow the manufacturer's installation procedures.

Insure that the stem has snapped before removing the rivet gun. After each rivet is installed, check for proper stem breakage and locking collar retention. The rivet stem should snap off even with the head of the rivet. The locking collar should be firmly seated into the locking recess of the rivet head.

Limited Blind Clearance Installation. In limited blind clearance applications, the manufactured head of the standard self-plugging (mechanical lock) blind rivets can protrude above the top sheet. The rivet head will be pulled down to the sheet as the stem is pulled in.

In some places, such as near the trailing edge of a control surface, there may not be sufficient space between the two surfaces to insert the rivet. In such cases, the pin may be forced into the hollow shank until the head of the pin just touches the end of the shank. Since no further shank expansion will result, the drill hole should not be enlarged to provide a free fit of the already expanded rivet. To insert the rivet, use a hollow drift pin which will accommodate the rivet pin and the locking collar. (See fig. 1-15.) This allows a driving force to be exerted on the head of the rivet. Drive the head into firm contact with the sheet and then apply the rivet pull tool in the usual manner to upset the rivet.

When problems occur during installation, the source of trouble could be in the installer, the tools or the application. Consequently, the following trouble-shooting guide (applicable to both bulbed and standard Cherrylock rivets) will consider sources of each problem and provide a solution for each.

a. Rivet stem pull through or breaks high.

	Source of Problem	*Solution*
(1)	Pulling head shifts too late.	-Readjust pulling head to shift sooner.
(2)	Rivet installed in oversize hole.	-Drill smaller holes or use larger diameter rivets.

b. Rivet stem breaks low (collar does not set).

	Source of Problem	*Solution*
(1)	Rivet installed in undersize hole.	-Drill out holes to proper size.
(2)	Rivet installed in over maximum grip.	-Use longer grip rivet.
(3)	Holes slanted or misaligned.	-Use more care in preparing holes.
(4)	Installer "cocks" pulling head.	-Use more care in aligning installation tools.

c. Rivet stem breaks low (collar does set).

	Source of Problem	*Solution*
(1)	Pulling head shifts too soon.	-Readjust pulling head.
(2)	Wrong type pulling head rivet set.	-Universal head rivets should be installed with universal style head sets.

d. Locking collar does not set.

	Source of Problem	*Solution*
(1)	Rivet installed in over maximum grip.	-Use longer grip rivets.
(2)	Chips prevent anvil from setting collar.	-Thoroughly clean and readjust pulling head rivet set.
(3)	Rivet installed in undersized hole.	-Drill out holes to proper size.
(4)	Pulling head shifts too late.	-Readjust pulling head.

e. Poor Head Seating.

	Source of Problem	*Solution*
(1)	Holes slanted or misaligned.	-Use more care in hole preparation.
(2)	Countersink not concentric with hole.	-Use countersink pilot which is close to hold size.

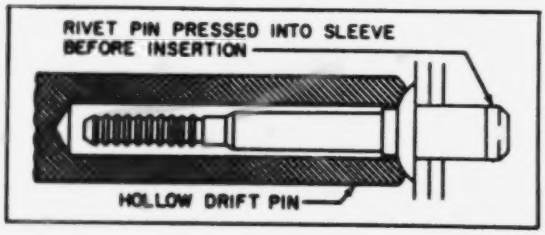


Figure 1-15. Mechanical lock blind rivet installation—limited clearance.

Removal Procedures. Removal of self-plugging (mechanical lock) blind rivets can easily be accomplished without damage to the work surface by the plished without damage to the work surface by use of the following procedures: (See fig. 1-16.)

a. Shear the lock by driving out the pin, using a tapered steel drift pin not over 3/32-inch diameter. If working on this material, back up the material while driving out the pin. If inaccessibility prohibits this, partially remove the rivet head by filing, or with a rivet shaver. An alternative would be to file the pin flat, center punch the flat, and carefully drill out the tapered part of the pin forming the lock.

b. Pry the remainder of the locking collar out with a drift pin.

c. Use the proper size drill to drill nearly through the rivet head. For a 1/8-inch diameter rivet, use a number 31 drill; for a 5/32, use a number 24; and for a 3/16, use a number 15.

d. Break off the drilled head, using a drift pin as a pry. NOTE: Do not drill completely through the sleeve to remove the rivet as this will tend to enlarge the hole.

e. Drive out the remainder of the rivet with a drift pin having a diameter equal to, or slightly less than, the rivet diameter.

Exercises (604):

1. What should you do to insure the best results when installing self-plugging (mechanical lock) blind rivets?

2. What factors influence the type of installation tools you will use when installing self-plugging (mechanical lock blind rivets?

3. At what time during the installation sequence of a self-plugging (mechanical lock) blind rivet does the stem break off flush with the head of the rivet?

4. Why are the recommended twist drill sizes for standard and bulbed type self-plugging (mechanical lock) blind rivets different?

5. What must be done in work situations involving the removal of self-plugging (mechanical lock) blind rivets in this material?

6. In limited blind clearance areas, what tool is used to insert a self-plugging (mechanical lock) blind rivet that has been partially expanded?

7. When removing countersunk self-plugging (mechanical lock) blind rivets, what power tool can be used to form a flat surface for centerpunching prior to drilling?

605. Give significant details relating to the inspection of installed self-plugging mechanical lock blind rivets.

Stem Inspection. Visual inspection of the seating of the pin in the manufactured head is the most reliable and simplest means of inspecting mechanical lock rivets. (See fig. 1-17.) If the proper grip range has been used and the locking collar and broken end of the stem are approximately flush with the manufactured head, the rivet has been properly upset and the lock formed. Insufficient grip length is indicated by the stem's breaking below the surface of the manufactured hand. In either case, the locking collar might not be seated properly, thus forming an unsatisfactory lock.

Gap Limitations. Gaps between rivet and the surface are permitted provided they meet TO specifications. The following are examples of TO gap limitations, which, if exceeded, are causes for rivet rejection. rejection.

a. Gaps caused by burrs or foreign material shall be cause for rejection.

b. Gaps under the head of protruding head rivets must meet the following when measured at the rivet shank, provided some portion of the rivet head is in contact with the sheet.

Gap Limits

Rivet Size	*Max. Gap Inch*
1/8	0.004
5/32	0.006
3/16	0.008
1/4	0.008

c. Gaps under the head of flush rivets, when measured at the rivet shank, must not exceed 0.002 of an inch, provided 60 percent of the rivet head is in bearing with the countersunk or dimpled hole.

d. Gaps between faying surfaces of riveted members must not exceed five percent of the thickness of the thinnest member when measured at the shank of the fastener. No more than two adjacent fasteners shall have the maximum permissible, and, in no case, shall the maximum gap exceed 0.015 of an inch.

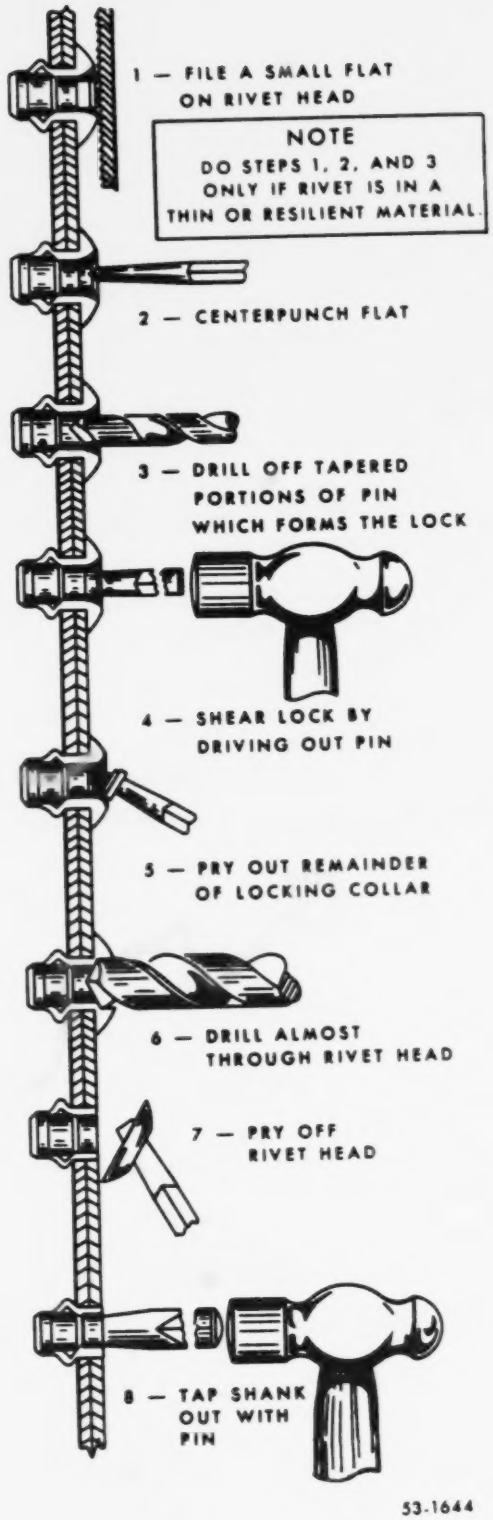

1 — FILE A SMALL FLAT ON RIVET HEAD
NOTE
DO STEPS 1, 2, AND 3 ONLY IF RIVET IS IN A THIN OR RESILIENT MATERIAL.
2 — CENTERPUNCH FLAT
3 — DRILL OFF TAPERED PORTIONS OF PIN WHICH FORMS THE LOCK
4 — SHEAR LOCK BY DRIVING OUT PIN
5 — PRY OUT REMAINDER OF LOCKING COLLAR
6 — DRILL ALMOST THROUGH RIVET HEAD
7 — PRY OFF RIVET HEAD
8 — TAP SHANK OUT WITH PIN
53-1644

Figure 1-16. Mechanical lock blind rivet removal sequence.

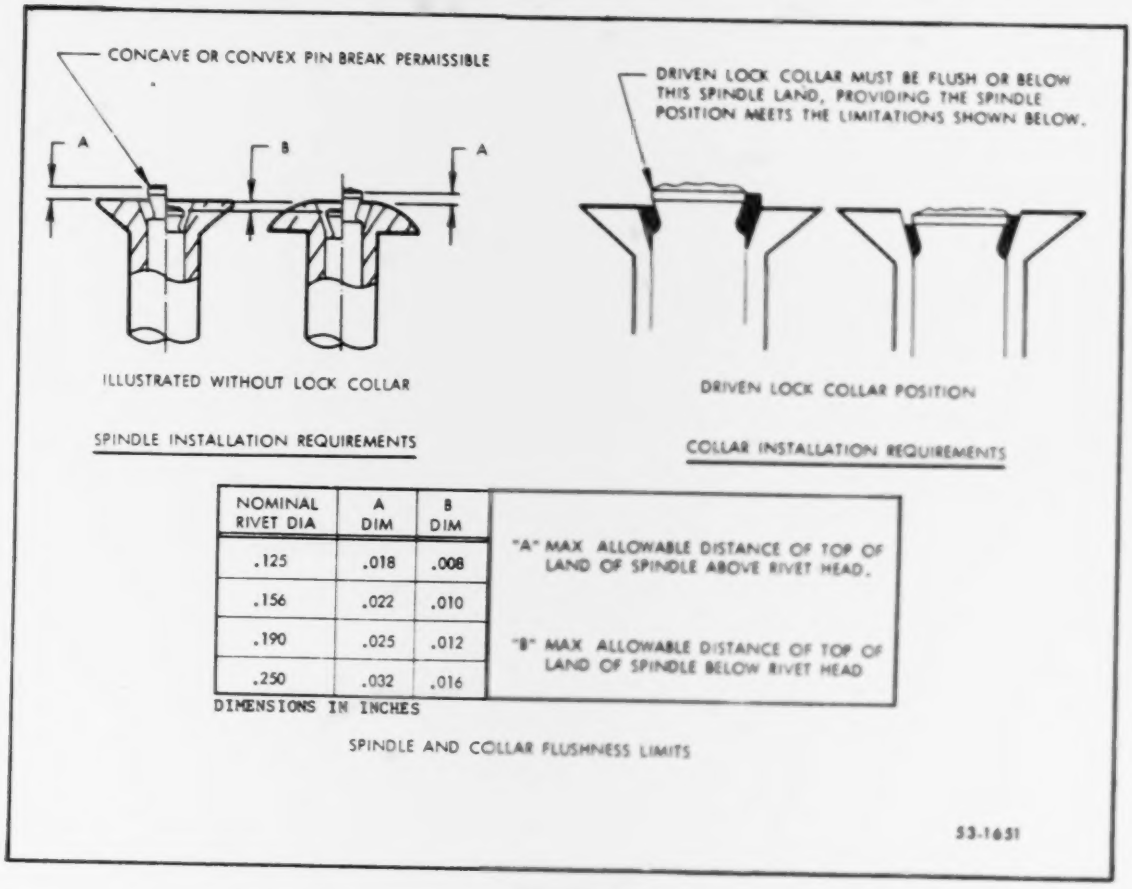

CONCAVE OR CONVEX PIN BREAK PERMISSIBLE
A
B
A
ILLUSTRATED WITHOUT LOCK COLLAR
SPINDLE INSTALLATION REQUIREMENTS
DRIVEN LOCK COLLAR MUST BE FLUSH OR BELOW THIS SPINDLE LAND, PROVIDING THE SPINDLE POSITION MEETS THE LIMITATIONS SHOWN BELOW.
DRIVEN LOCK COLLAR POSITION
COLLAR INSTALLATION REQUIREMENTS
NOMINAL RIVET DIA | A DIM | B DIM
.125 | .018 | .008
.156 | .022 | .010
.190 | .025 | .012
.250 | .032 | .016
"A" MAX. ALLOWABLE DISTANCE OF TOP OF LAND OF SPINDLE ABOVE RIVET HEAD.
"B" MAX. ALLOWABLE DISTANCE OF TOP OF LAND OF SPINDLE BELOW RIVET HEAD
DIMENSIONS IN INCHES
SPINDLE AND COLLAR FLUSHNESS LIMITS
53-1631

Figure 1-17. Mechanical lock blind rivet inspection.

In work situations where the shop head can be inspected, check for structurally inadequate blind heads. Superficial stretch marks which may appear in the rivet sleeve are not detrimental to rivet strength and are acceptable.

Exercises (605):

1. What is the main cause when the stem of a mechanical lock blind rivet breaks off below the surface of the manufactured head?

2. Excessive grip length will cause the stem of mechanical lock blind rivets to break-off at what position in relation to the manufactured head?

3. If 60 percent of a countersunk mechanical lock blind rivet is bearing against the surface, what is the maximum gap allowed between the rivet head and surface area?

4. What is maximum gap permitted between the manufactured head ot a 5/32nd universal head mechanical lock blind rivet and the work surface?

5. How is the strength requirements of self-plugging (mechanical lock) blind rivets affected by superficial stretch marks formed on the shop head during installation?

1-3. Pull-Thru Blind Rivets

Pull-thru blind rivets are used where the structural requirements do not call for a solid shank rivet or a self-plugging blind rivet. With the introduction of stronger material compositions for sleeve construction pull-thru rivets are being used for the attachment of structural hardware, such as nut plates and channel nut assemblies. This section is designed to acquaint you with the uses of pull-thru blind rivets.

606. State the principal features of pull-thru blind rivets and explain aspects of installation and removal procedures.

Principal Features. This type of blind mechanically expanded rivet consists of two parts: a serrated stem and a hollow sleeve. It differs from the two previously discussed blind rivets in that the stem is pulled completely through the sleeve of the rivet during installation, as shown in figure 1-18. It is structurally weak because of the hollow center created after the installation is completed. It should be used only where allowed by TO specifications.

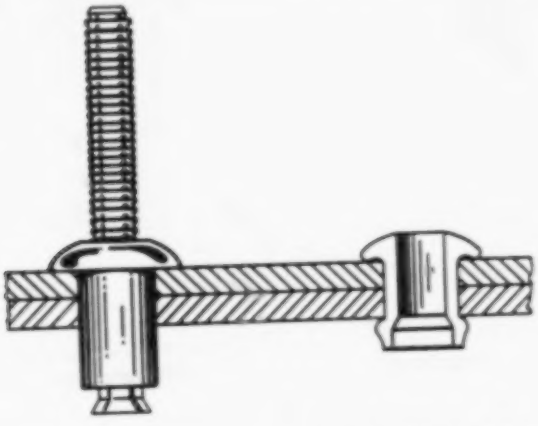


Figure 1-18. Pull-thru blind rivets.

Pull-thru blind rivets are available in a variety of head styles, material compositions, and diameters. Most of your work will involve the use of the countersunk steel, 3/32nds of an inch in diameter type. You will use this type to install nut plates and channel nut assemblies. Figure 1-19 is a data sheet for a 100° steel pull-thru blind rivet. Take a few minutes and study the data given. Problems of replacing nut plates and channel nut assemblies in blind areas and areas of limited access are eliminated by using the steel pull-thru blind rivets. Also damage to the skin surface and nut plate assemblies caused by a misplaced bucking bar are eliminated.

Steel pull-thru rivets used to install nut plates have high torque-out and push-out strengths. For a 10/32 bolt it would take 60 inch-pounds of torque to shear the rivets and 100 pounds of push-out pressure to break the nut plate loose. Both powered and hand operated installation tool are available for pull-thru rivets. Our discussion will be directed toward the hand operated rivet gun.

Installation Procedures. The combined thicknesses of the material and the nut plate are used to determine the grip length required. Once you have determined the grip length, align the nut plate with the existing rivet holes. It is important that the nut plate be clamped tightly against the surface of the material during rivet installation. Gaps between the surface and the nut plate will allow the rivet to swell between them causing the fastener hole to be misaligned.

After the nut plate is aligned and clamped in place, insert the rivet stem into the pulling head of the rivet gun. Insert the rivet into the rivet hole, holding the pulling head firmly and squarely against the head of the rivet and in line with the rivet stem as shown in figure 1-20. Maintaining a steady pressure against the rivet head, squeeze the handles to install the rivet. An additional stroke may be necessary depending on the rivet length and material thickness.

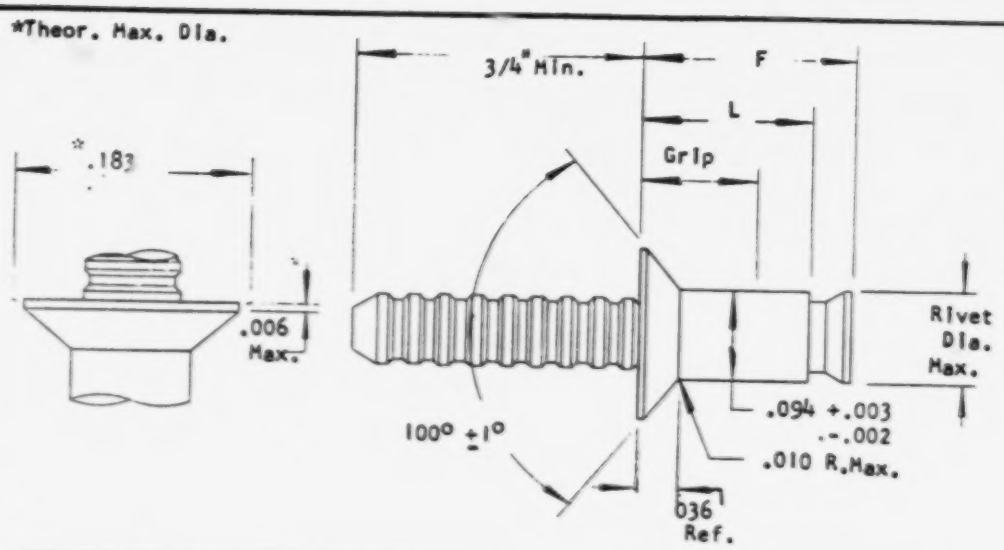
After the rivets are installed check the alignment of the bolt or screw hole. This can best be accomplished by hand-starting a bolt into the fastener hole. Also while the bolt is in place, move it back and forth, checking the tightness of the rivets. Any movement by the rivets indicate that the nut plate is not tight and must be replaced.

Removal Procedures. The absence of a stem in a pull-thru rivet makes the removal relatively simple. Drill off the head of rivet, making sure not to damage the countersunk or dimpled area of the hole. Take a drift punch and punch out the remaining portion of the sleeve. When drilling out pull-thru blind rivets, make a reasonable effort to remove the blind end which was punched into the structure. If you cannot remove the blind end, remove as many pieces as possible.

Exercises (606):

1. How does the pull-thru blind rivet compare to the self-plugging blind rivet in strength requirements?

2. In what type of repair situation are you most likely to install pull-thru blind rivets?



Length Dash No.	Grip Range Min.	Grip Range Max.	L Max.	F Max.
-3-1	up to	.062	.140	.218
-3-2	.063	.125	.203	.281
-3-3	.126	.187	.265	.343
-3-4	.188	.250	.328	.405
-3-5	.251	.312	.390	.468
-3-6	.313	.375	.453	.530
-3-7	.376	.437	.515	.593
-3-8	.438	.500	.578	.655
-3-9	.501	.562	.640	.718
-3-10	.563	.625	.703	.780
-3-11	.626	.687	.765	.843
-3-12	.688	.750	.828	.905

Recommended Drilling Procedure	
Size Drill	Hole Limits
#40 (.098)	.097/.101

1. Shank Dia. to be measured within 0.1" of base of Head
2. Mat'l: Sleeve = C1018 Steel
   : Stem = Steel
3. Finish: Sleeve = Cadium Plate, QQ-P-416 Type II Class 3 and bake
   Stem = #18 Max.
4. Grip lengths are test proven for use in mat'l thickness 1/64 or .015 thicker than grip indicated

53-1660

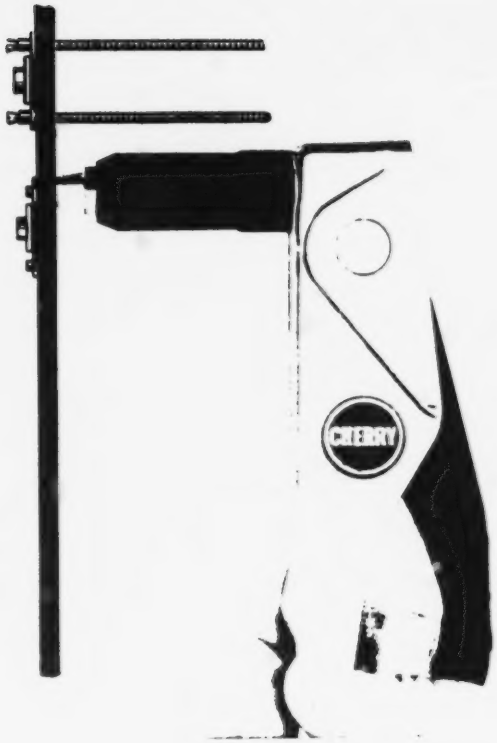
Figure 1-19. Steel pull-thru blind rivet data.

3. Why is it necessary to insure that parts being riveted together with pull-thru blind rivets be tightly clamped against the surface before installing rivets?

4. What determines the number of strokes required to install pull-thru blind rivets when using a hand operated pulling-gun?

5. After a nut plate or channel assembly is riveted in place using pull-thru blind rivets, what must you do to insure the installation was performed correctly?

6. When removing pull-thru rivets, what should you avoid damaging?



53-1661

Figure 1-20. Pull-thru blind rivet installation.

High Strength Fasteners

CERTAIN AREAS OF AN aircraft require a fastener far beyond the strength obtainable from the self-plugging blind rivets we discussed in the previous chapter. For these areas, special high strength fasteners are used. High strength fasteners are available in a variety of types and designs for use in open and/or blind areas of an aircraft.

This chapter is designed to introduce to you the characteristic features, installation, and removal procedures associated with high strength fasteners. The fasteners covered are those that you are most likely to be called upon to install. In cases involving an unknown type of high strength fastener, always look for information in the -3 TO for the specific aircraft involved.

2-1. Open Area High Strength Fasteners

Just like that of solid shank rivets, the installation of certain high strength fasteners requires that you have access to both sides of the structure being fastened together. The results obtained by high strength fasteners will be directly related to how well you prepare the parts being fastened. Hole preparation, proper grip length and diameter, and correct installation procedures are just a few of the critical points that will be stressed in the following objectives.

607. Identify the principal features of Hi-Shear rivets and supply details of the factors used to select Hi-Shear rivets for installation.

Hi-Shear Rivets. Hi-Shear (trade name) rivets are essentially treadless bolts used in place of regularly threaded bolts. Hi-Shear rivets consist of a pin and a collar. The pin is headed at one end and is grooved with a shearing edge at the other end. (See fig. 2-1.) Hi-Shear rivets are designed to be used only in shear applications. Hi-Shear rivets have the same shear strength as bolts of equal diameter about 40 percent of the weight of a bolt. They require only about one-fifth as much time for installation as a bolt, nut, and washer combination. They are approximately three times as strong as solid shank rivets. They are, perhaps, the oldest type of high strength rivet type fastener used in aircraft construction.

Hi-Shear rivets are fabricated in a variety of material compositions. The pins are fabricated from either aluminum alloy, steel, stainless steel or titanium. The collar that locks the pin in place is fabricated from either aluminum alloy, steel, stainless steel, or monel. Factors such as area of installation, strength requirements, and composition of material being fastened are items that will determine the material composition of the pin and collar used. The different material compositions of Hi-Shear rivet pins can be readily identified by head markings, as shown in figure 2-2. Hi-Shear rivets are manufactured in a number of head styles. The most common ones you will use are the countersunk and flat head styles.

Selection factors. Because the shear strength of Hi-Shear rivets is usually greater than either the shear or bearing strength of the aluminum alloys they are installed in, Hi-Shear rivets are used to greater advantage only in thick gage materials. They are never used where the grip length is less than the shank diameter of the pin. The 100° countersunk type is used where flush surfaces are desired. The flat head is used in other areas.

The diameter of Hi-Shear rivets is measured in 1/32nds of an inch. The grip length is measured in 1/16ths of an inch. The proper length can be determined in two ways—one by measuring, the other by trial and error. The measurement method consists

Figure 2-1. Hi-Shear rivet parts.

RIVET BASIC CODE NUMBER	HEAD STYLE	MATERIAL HEAT TREATMENT SHANK TOLERANCES	HEAD IDENTIFICATION MARKINGS					
			HI-SHEAR RIVET TOOL CO.	PHEOLL MFG. CO.	NATIONAL SCREW & MFG. CO.	AMERICAN SCREW CO.	CONTINENTAL SCREW CO.	VOI-SHAN MFG. CO.
NAS1055 NAS1054	FLUSH PROTRUDING	ALLOY STEEL 160,000-180,000 PSI CLOSE TOLERANCE	H H	P P	N N	A A	C C	VS VS
NAS525 NAS529	FLUSH PROTRUDING	ALLOY STEEL 160,000-180,000 PSI CLOSE TOLERANCE	H	P PU		A	U C	VS VSU
HS23 HS26	FLUSH PROTRUDING	7075-T6 ALUM. ALLOY CLOSE TOLERANCE	H	P			C	VS
NAS177 (1) NAS178 (1)	FLUSH PROTRUDING	ALLOY STEEL 125,000-150,000 PSI STANDARD TOLERANCES	+	P+	+	A+ X	+	VS+
HS47 (1) HS48 (1)	FLUSH PROTRUDING	ALLOY STEEL 160,000-180,000 PSI STANDARD TOLERANCES	H	PH P	N NH	A AH	C H	VS
HS37P (3) HS38P (4)	FLUSH PROTRUDING	ALLOY STEEL 160,000-180,000 PSI CLOSE TOLERANCE	▽	P△		A△	△	VS△
HS51P (3) HS52P (4)	FLUSH PROTRUDING	ALLOY STEEL 160,000-180,000 PSI CLOSE TOLERANCE	H	P PU		A	U	VS VSU
HS61 HS62	FLUSH PROTRUDING	431 STAINLESS STEEL 125,000 PSI MIN. CLOSE TOLERANCE	61 62	61 62				VS 61 VS 62
HS91 HS92	FLUSH PROTRUDING	A286 STEEL 95,000 PSI MIN. CLOSE TOLERANCE	91 92					VSN
HS39P (5) HS40P (6)	FLUSH PROTRUDING	ALLOY STEEL 160,000-180,000 PSI CLOSE TOLERANCE	•/64	P•/64	N/64 N•/64	A/64 A•/64	•/64	VS•/64
HS41P (7) HS42P (8)	FLUSH PROTRUDING	ALLOY STEEL 160,000-180,000 PSI CLOSE TOLERANCE	•/32 ‡/32	PP P/32	N/32 N‡/32	A/32 A‡/32	•/32 P	VS‡/32
HS139 (9) HS140 (10)	FLUSH PROTRUDING	431 STAINLESS STEEL 125,000 PSI MIN. CLOSE TOLERANCE	139 140	P139 P140				VS 139 VS 140
HS141 (11) HS142 . (12)	FLUSH PROTRUDING	431 STAINLESS STEEL 125,000 PSI MIN. CLOSE TOLERANCE	141 142	P141 P142				VS 141 VS 142

Notes

(1) THIS RIVET HAS BEEN REPLACED BY NAS1055 RIVET.
(2) THIS RIVET HAS BEEN REPLACED BY NAS1054 RIVET.
(3) THIS RIVET HAS BEEN REPLACED BY NAS525 RIVET.
(4) THIS RIVET HAS BEEN REPLACED BY NAS529 RIVET.
(5) THIS IS A REPAIR RIVET FOR NAS1055 AND NAS525 AND HAS A 1/64 INCH OVERSIZE DIAMETER.
(6) THIS IS A REPAIR RIVET FOR NAS1054 AND NAS529 AND HAS A 1/64 INCH OVERSIZE DIAMETER.
(7) THIS IS A REPAIR RIVET FOR NAS1055 AND NAS525 AND HAS A 1/32 INCH OVERSIZE DIAMETER.
(8) THIS IS A REPAIR RIVET FOR NAS1054 AND NAS529 AND HAS A 1/32 INCH OVER SIZE DIAMETER
(9) THIS IS A REPAIR RIVET FOR HS61 AND HAS A 1/64 INCH OVERSIZE DIAMETER.
(10) THIS IS A REPAIR RIVET FOR HS62 AND HAS A 1/64 INCH OVERSIZE DIAMETER.
(11) THIS IS A REPAIR RIVET FOR HS61 AND HAS A 1/32 INCH OVERSIZE DIAMETER.
(12) THIS IS A REPAIR RIVET FOR HS62 AND HAS A 1/32 INCH OVERSIZE DIAMETER.

53-1691

Figure 2-2. Hi-shear rivet head markings.

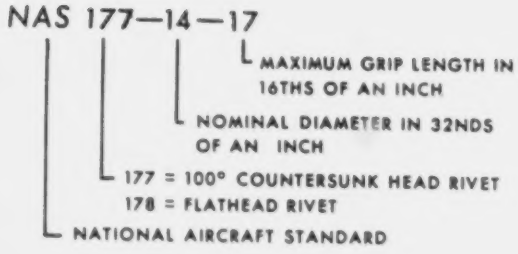

NAS 177—14—17
MAXIMUM GRIP LENGTH IN 16THS OF AN INCH
NOMINAL DIAMETER IN 32NDS OF AN INCH
177 = 100° COUNTERSUNK HEAD RIVET
178 = FLATHEAD RIVET
NATIONAL AIRCRAFT STANDARD
53-1716

Figure 2-3. Hi-Shear rivet part number breakdown.

of measuring the combined thicknesses of the material being riveted to obtain the grip length required. The trail and error method involves inserting various lengths of the correct diameter Hi-Shear pins, until no more than 1/16 of an inch of the straight portion of the shank extends through the material. Regardless of the method used to determine the length, the straight portion of the shank should *not* extend more than 1/16 of an inch through the material.

When the required length is not available, a pin of the next length may be used with washers to adjust the grip length. Cadmium plated steel washers are used with steel collars; but either cadmium plated steel or aluminum washers may be used with aluminum collars. The total washer thickness must not exceed .096 of an inch. The washer may be positioned on the rivet head side of the material when a flathead rivet is used.

Separate part numbers are used to identify the Hi-Shear pins and collars. Figure 2-3, illustrates the breakdown of a part number for a Hi-Shear pin. A basic part number for a collar would be NAS 179-4. The number 179 denotes a specific type of collar. The -4 indicates the inside diameter of the collar, measured in 1/32nd increments.

Exercises (607):

1. Name the two parts that make up a Hi-Shear rivet?

2. How does a Hi-Shear rivet compare with a bolt of equal diameter?

3. How does a Hi-Shear rivet compare with a solid rivet of equal diameter?

4. What factors determine the material composition of Hi-Shear rivets to be selected for a repair situation?

5. What fractional measurements are used to indicate the diameter and grip length of Hi-Shear rivets?

6. Regardless of the method used to determine the required grip length for a repair situation, what must you remember?

7. What type head styles of Hi-Shear rivets are you likely to use most often?

8. What method is used to identify the material composition of Hi-Shear rivets?

9. Why are washers sometimes used under the head or collar of Hi-Shear rivets?

608. State pertinent details related to the instllation, inspection, and removal of Hi-Shear rivets.

Installation tools. Hi-Shear rivets are installed with standard bucking bars and pneumatic riveting hammers. They require the use of a special gun set that incorporates collar swaging and trimming and a discharge port through which excess collar material is ejected. A separate size set is required for each shank diameter.

Hole preparation. Holes drilled for Hi-Shear rivets must be drilled as accurate as possible and within tolerances given in TO specifications. Hi-Shear rivets do not expand during installation; therefore, they must fit the hole into which they are installed. All burrs must be removed from the outside of the rivet hole and from between the material being fastened. At times, it is necessary to spotface the area under the head or collar of Hi-Shear rivets. Spotfacing is used under the head of a Hi-Shear rivet when the surface is not level. Spotfacing is not under the collar *unless* the angle of the surface is not perpendicular to the centerline of the rivet hole by more than 5° and when the radius of the curved surface under the collar is less than three times the diameter

of the pin. The size of the spotfaced area for the head must be at least 1/16 of an inch greater than the diameter of the pin's head. In the case of the collar area, the spotfaced area must be large enough to allow for riveting tool clearance. If spotfacing is required, it will be called for in TO specifications which will also give the correct spotface diameter and radius on the cutter required.

When countersinking holes for Hi-Shear rivets, be sure that the countersunk hole is not too deep. When the head of the pin is below the surface, the head will back-up to the bucking bar when the collar is driven, resulting in a gap between the head of the pin and the surface of the countersunk hole.

Installation procedures. Normally, Hi-Shear rivets are driven from the collar side, with a bucking bar being held against the manufactured head. When space limitation will not permit the use of a rivet gun on the collar side, then a driving tool held in a bucking bar may be held against the collar, while a rivet gun with a flush set is used against the head of the rivet. Procedures to use when driving a Hi-Shear from the collar side are these:

Step 1. Insert the Hi-Shear into the work material. The grooved edge of the pin must be outside the work surfaces as shown in the section dealing with checking for correct grip length on figure 2-4. If the grooved edge of the pin is below the surface of the material, a longer pin is needed.

Step 2. If the length of the pin is correct, place a bucking bar against the head of the pin as shown in the portion of figure 2-4 covering the installation procedures.

Step 3. Slip the collar over the grooved end of the pin. The shearing edge of the pin must be below the top of the collar, as illustrated in figure 2-4. If the shear edge of the pin is above the top of the collar, a washer may be used under the head of the collar.

Step 4. If the shear edge of the pin is correct, place a previously selected rivet set and gun under the collar.

Step 5. Align the gun so that it is perpendicular to the material, as shown in figure 2-4.

Step 6. Depress the trigger on the gun, apply pressure to the rivet collar. This action will cause the rivet collar to swage into the groove on the rivet end as shown in the lower left hand corner of figure 2-4. Rolling or rocking of the rivet gun is not permitted as this action produces an unsatisfactory installation.

Step 7. Continue the driving action until the collar is properly formed and excess collar material is trimmed off as illustrated in the lower right hand corner of figure 2-4.

When Hi-Shear rivets are to be installed in parts which have had sealant applied to their faying surfaces, remember the following key points:

a. When sealant is used, apply temporary fasteners in every other hole to obtain proper sealant squeeze out.

b. All rivets shall be installed before the sealant cures.

c. When the pin is inserted into the hole, lightly tap the head with a soft-faced mallet. This insures proper setting of the pin in the hole.

d. Clean the exposed shank of the pin and surface around the hole; removing any sealant residue.

e. Use a clean locking collar when driving the rivet.

NOTE: When making a repair involving the installation of new Hi-Shear fastener location, always consult the specific TO of the aircraft being repaired for fastener spacing (edge distance, transverse pitch, and rivet pitch).

Inspection criteria. After driving Hi-Shear rivets, inspect both sides of the rivet. The head of the pin must not be marred and must fit tightly against the surface. No gaps are permitted between the collar and pin or between the collar and metal surface.

Removal procedures. The conventional method of removing rivets by drilling off the head may be used to remove Hi-Shear rivets. This method is very difficult, but you may have to use it when the collar is not easily accessible. Drill through the head with a twist drill the same size as the rivet shank, making sure the twist drill is centered. Drill only to the junction of the head and shank. Then, using a drift punch, hammer out the remaining portion of the pin with the collar still attached. Normally, you will use the chisel method, as shown in the top section of figure 2-5, to remove Hi-Shear rivets. To remove a Hi-Shear rivet by this method, split the collar on both sides of the pin with a chisel, being careful not to mar the surface of the sheet. After removing the collar, drive out the pin using a drift punch and hammer. Other methods of removing Hi-Shear rivets, such as the drill guide method and hollow end mill method are also shown in figure 2-5.

Precautions in using Hi-Shear rivets. Use of Hi-Shear rivets requires observance of certain precautions not associated with common, solid shank rivets.

a. Be sure sheets are clamped together firmly to avoid selecting a stud that is too long.

b. To assure that you use the correct length pin, drive a few test rivets into a material of thickness equal to that of the actual work. The straight portion of the shank should not protrude more than 1/16 inch through the work.

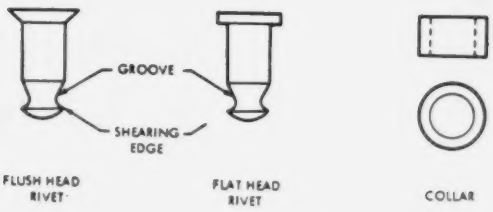
c. Be sure rivets fits snugly in the hole. Hi-Shear rivets do not expand to fill oversize holes.

d. Keep rivet set aligned with rivet pin so that the collar will seat evenly, shear off evenly, and be uniform around the rivet.

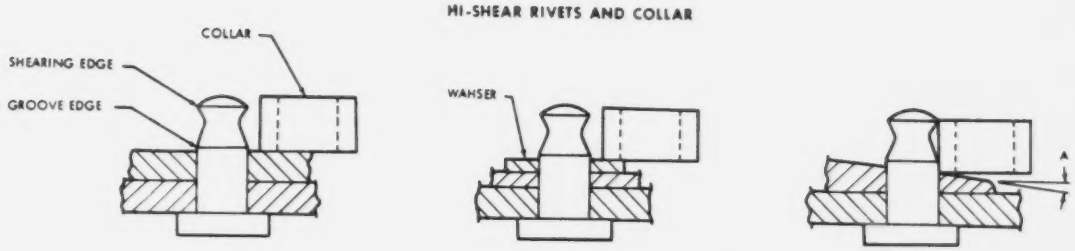
e. Be sure the holes are properly aligned. Hi-Shear rivets are used where shear loads are high and the amount of bearing surfaces is critical.

f. Do not overdrive the rivet more than 1/32 inch, or the tensile strength of the collar-formed head will be reduced.

g. Do not underdrive the rivet. An underdriven rivet indicates that the collar has not been swaged completely into the rivet groove, and the rivet may fail under full tension loads.



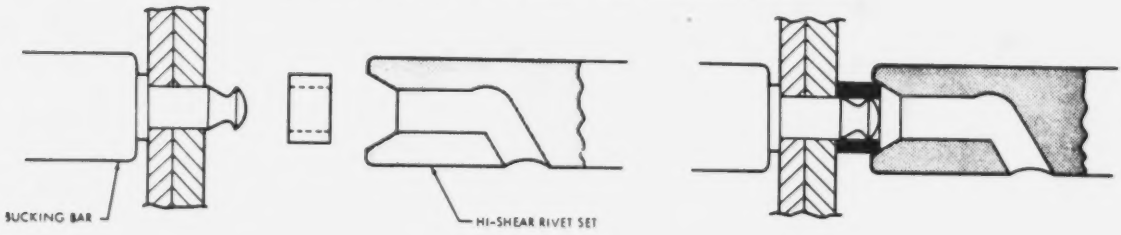
HI-SHEAR RIVETS AND COLLAR



RIVET SIZE	MAXIMUM SURFACE SLOPE (A)
1/8 INCH THRU 3/8 INCH	7 DEGREES
7/16 INCH THRU 1 INCH	4.5 DEGREES

GROOVE EDGE MUST BE OUTSIDE OF WORK.
SHEARING EDGE MUST BE BELOW TOP OF COLLAR.

CHECKING FOR CORRECT GRIP LENGTH AND PERMISSIBLE SURFACE SLOPE



STEP 1. THE HIGH-SHEAR PIN IS INSERTED INTO THE WORK. A BUCKING BAR IS PLACED AGAINST THE HEAD OF THE PIN.

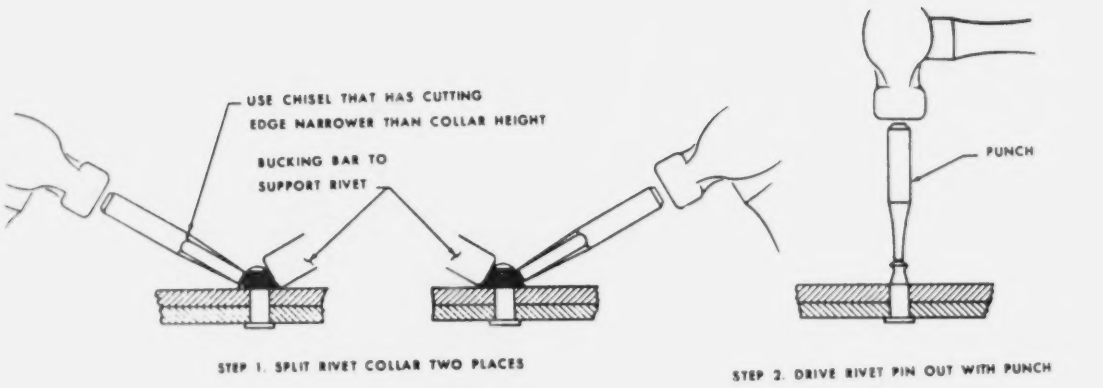
STEP 2. THE HIGH-SHEAR COLLAR IS SLIPPED OVER THE GROOVED END OF THE PIN. A HIGH-SHEAR GUN OR SQUEEZER SET IS PLACED OVER THE COLLAR.

STEP 3. AS DRIVING PRESSURE IS APPLIED, THE COLLAR BEGINS TO FORM INTO THE GROOVED END OF THE PIN.

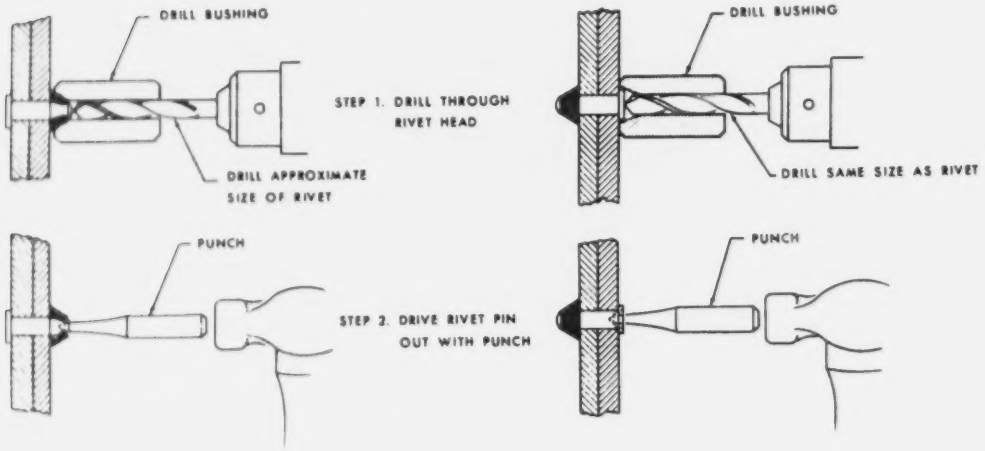
STEP 4. THE COLLAR IS FORMED OR SWAGED COMPLETELY INTO THE GROVED END OF THE PIN. EXCESS MATERIAL IS TRIMMED OFF COLLAR.

53-1692

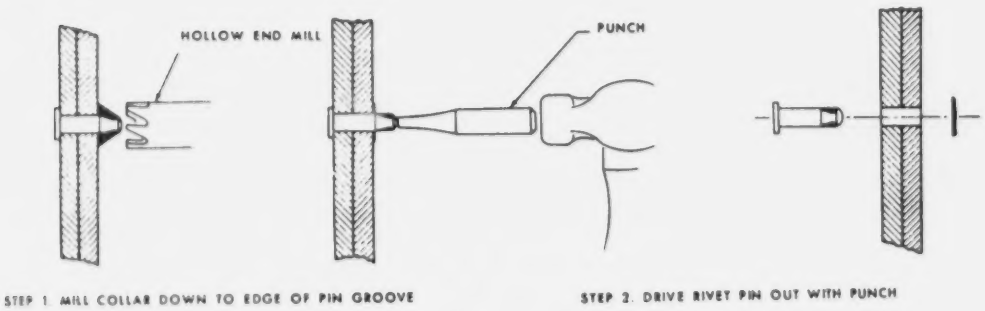
Figure 2-4. Hi-Shear rivet data.


USE CHISEL THAT HAS CUTTING EDGE NARROWER THAN COLLAR HEIGHT
BUCKING BAR TO SUPPORT RIVET
PUNCH
STEP 1. SPLIT RIVET COLLAR TWO PLACES
STEP 2. DRIVE RIVET PIN OUT WITH PUNCH

CHISEL METHOD



DRILL GUIDE METHOD



HOLLOW END MILL METHOD

53-1693

Figure 2-5. Hi-Shear removal procedures.

Exercises (608):

1. Why is it very important that holes drilled for Hi-Shear rivets be very accurate?

2. When is it necessary to spotface the area under the head of Hi-Shear rivets?

3. When is it necessary to spotface the area under the collar of Hi-Shear rivets?

4. What usually results when Hi-Shear fastener holes are over countersunk?

5. When is it necessary to drive Hi-Shear rivets from the manufactured head side?

6. If the grooved end of the Hi-Shear pin is below the surface of the material before installation, what must you do?

7. Where should the shear edge of the Hi-Shear pin be positioned prior to installation?

8. What results when you roll or rock the riveting gun during the installation of Hi-Shear rivets?

9. What results when the locking collar is overdriven more than 1/32 of an inch?

10. What is the recommended method of removing Hi-Shear rivets?

609. Name the types of lockbolt fasteners and state recommended practices concerning their use.

Lockbolt Fasteners. A lockbolt is a form of bolt combining the features of both a high-strength bolt and a rivet, with advantages over each. The lockbolt is generally used in wing splice fittings, landing gear fittings, fuel cell fittings, longerons, beams, skin splice plates, and other major structural attachments. It is easier and more quickly installed than the conventional rivet or bolt; and it eliminates the use of lockwashers, cotter pins, and special nuts. Like the rivet, lockbolt requires a pneumatic gun or pull gun for installation. When installed, the lockbolt is rigidly and permanently locked in place.

The types of lockbolts commonly used are pull, stump, and blind. These types are illustrated in figure 2-6.

Pull type lockbolt. Pull type lockbolts are used mainly in aircraft primary and secondary structures. They are installed very rapidly and have approximately one-half the weight of equivalent AN steel bolts and nuts. A special pneumatic pull gun is required to install this type lockbolt. Since bucking is not required to install this lockbolt, one person can do the job.

Pull type lockbolts are available in two types: those used in tension applications and those used in shear applications. You can easily see the difference between the two by checking the pins. Tension type pins have larger and thicker head designs and have from 4 to 5 locking grooves below the breakneck groove on the pin. The shear type pins have a thin head design, similar to the head designs of Hi-Shear rivets. Also, only two locking grooves are provided below the breakneck groove on shear type pins. Pull type lockbolts are fabricated in two head types—countersunk and protruding, both in tension or shear designs.

Stump type lockbolts. In figure 2-6, notice that the stump type lockbolt does not have the extended stem with pull grooves. Stump lockbolts, although they do not have the extended stem with pull grooves, are companion fasteners to pull type lockbolts. Stump lockbolts are used primarily where clearance does not permit installation of pull type lockbolts. A standard pneumatic riveting hammer (with a hammer set attached for swaging the collar into the pin locking grooves) and a bucking bar are required to install stump type lockbolts.

Stump type lockbolts are available in both shear and tension types and are identified by the same characteristic features discussed for the pull type lockbolt. Countersunk and protruding head styles are also available.

Blind type lockbolts. Blind type lockbolts come as complete units or assemblies. They have exceptional strength and sheet pull-together characteristics. Blind lockbolts are used where only one side of the work is accessible and, generally, where it is difficult to drive a conventional rivet. This type of lockbolt is installed in the same manner as the pull type lockbolt. (See fig. 2-6).

Blind type lockbolts. Blind type lockbolts come as complete units or assemblies. They have exceptional strength and sheet pull-together characteristics. Blind lockbolts are used where only one side of the

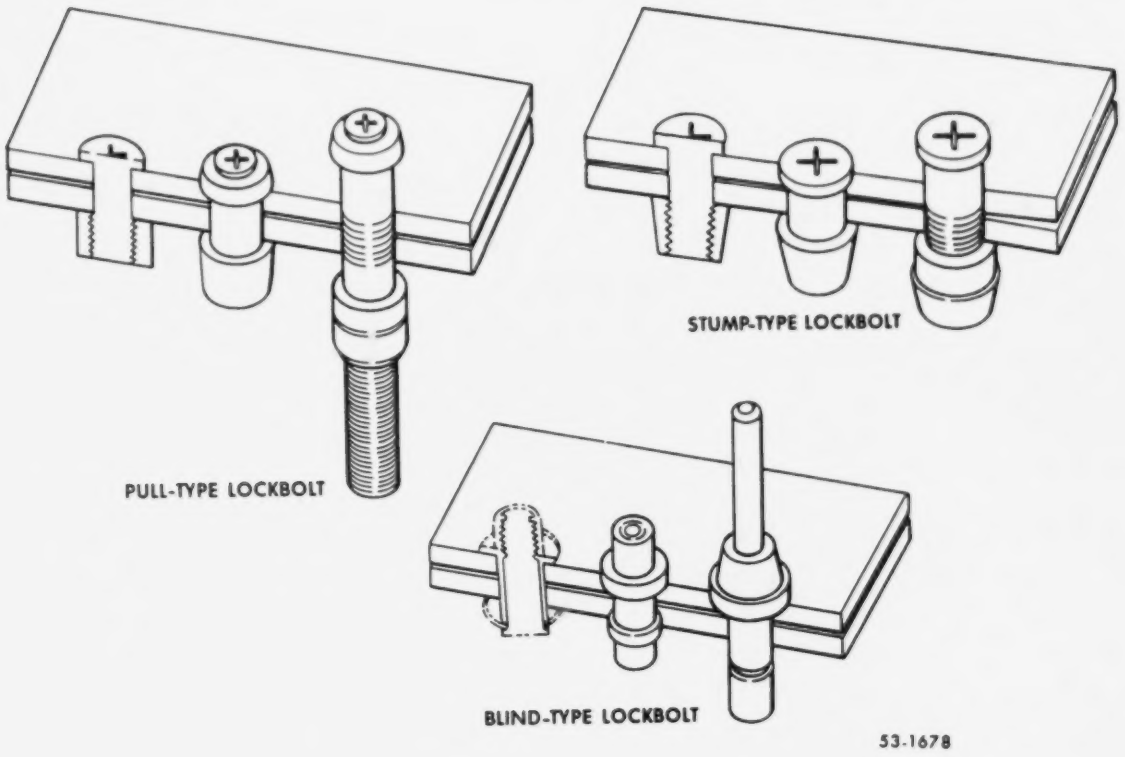


Figure 2-6. Types of lockbolts.

work is accessible and, generally, where it is difficult to drive a conventional rivet. This type of lockbolt is installed in the same manner as the pull type lockbolt. (See fig. 2-6.)

Common features of the three types of lockbolts are the annular locking grooves on the pin and the locking collar, which is swaged into the pin's lock grooves to lock the pin in tension. The pins of the pull and blind type lockbolts are extended for pull installation. The extension is provided with pulling grooves and a tension breakoff groove.

Material Composition. The pins of pull and stump type lockbolts are made of heat-treated alloy steels or high strength aluminum alloys. Companion collars are made of aluminum alloys (2024-T4, 6061-T6), mild steel, or monel. The blind lockbolt consists of a heat-treated alloy steel pin, blind sleeve and filler sleeve, mild steel collar, and carbon steel washer. The material of which the stump and pull type lockbolts are made can be identified by the markings on the head of the pin. Figure 2-7, illustrates various types of head markings used for lockbolts. Additional

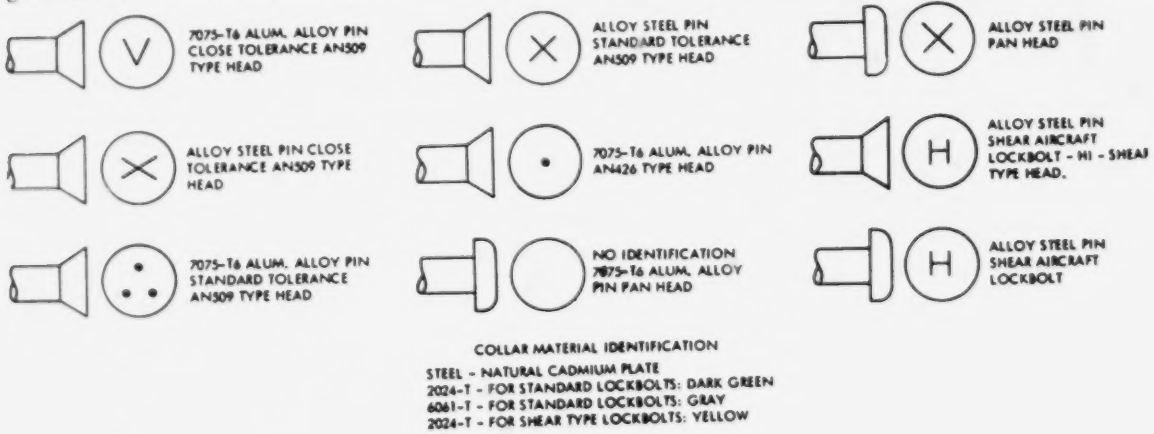

7075-T6 ALUM. ALLOY PIN CLOSE TOLERANCE AN509 TYPE HEAD
ALLOY STEEL PIN STANDARD TOLERANCE AN509 TYPE HEAD
ALLOY STEEL PIN PAN HEAD
ALLOY STEEL PIN CLOSE TOLERANCE AN509 TYPE HEAD
7075-T6 ALUM. ALLOY PIN AN426 TYPE HEAD
ALLOY STEEL PIN SHEAR AIRCRAFT LOCKBOLT - HI - SHEAR TYPE HEAD.
7075-T6 ALUM. ALLOY PIN STANDARD TOLERANCE AN509 TYPE HEAD
NO IDENTIFICATION 7075-T6 ALUM. ALLOY PIN PAN HEAD
ALLOY STEEL PIN SHEAR AIRCRAFT LOCKBOLT
COLLAR MATERIAL IDENTIFICATION
STEEL - NATURAL CADMIUM PLATE
2024-T - FOR STANDARD LOCKBOLTS: DARK GREEN
6061-T - FOR STANDARD LOCKBOLTS: GRAY
2024-T - FOR SHEAR TYPE LOCKBOLTS: YELLOW

Figure 2-7. Lockbolt head markings.

head markings can be identified by consulting TO 1-1A-8.

The collars are colored coded for easy identification. Collars fabricated from aluminum alloy 2024-T4, are identified by the colors green, blue, yellow, or beige based on the type collar. Collars fabricated from 6061-T6 are colored gray. Monel collars are black, and the mild steel collars are colored either gold or silver.

Sizes. Pull and stump type lockbolts are available in 3/16, 1/4, 5/16, and 3/8 of an inch in diameters. Blind lockbolts are available in oversize 1/4 and 5/16 of an inch in diameters. Diameters are measured in increments of 32nds of an inch. The grip length is measured in increments of 1/16th of an inch.

Uses. Alloy steel lockbolts may be used to replace steel Hi-Shear rivets, solid steel rivets, and AN or MS bolts of the same diameter and head type. Aluminum alloy lockbolts may be used to replace 7075-T aluminum alloy Hi-Shear rivets and solid aluminum alloy rivets of the same diameter and head type. Steel and aluminum alloy lockbolts may also be used to replace steel and 2024-T aluminum alloy bolts of the same diameter, respectively. Blind lockbolts may be used to replace aluminum alloy rivets of the same diameter. For shear application, the blind type lockbolt may be used to replace aluminum alloy or steel AN and MS bolts, AN MS screws, and Hi-Shear rivets of the same diameter.

Numbering system. The following examples explain the significance of the NAS numbering system used for lockbolt pins and collars:

Example 1. - NAS2506V8
(Pin)
- NAS - National Aerospace Standard.
- 2506 - (250) Indicates head style (100° countersunk); (6) indicates the maximum grip range, measured in 1/16 of an inch. In this example, the grip range is ⅜ of an inch.
- V - Indicates material composition (6A1-4V titanium alloy).
- 8 - Indicates diameter of the pin measured in 32nds of an inch.

In this example, the diameter is 3/16ths of an inch.

NOTE: If the letter H is used in place of the letters NAS (H2506V8), this would indicate that the pin has an escape groove in the shank, for sealant applications.

Example 2. - NAS 1080-C6
(Collar)
- NAS - National Aerospace Standards.
- 1080 - Type of collar (tension or shear applications).
- C - Material Composition - 2024-T4.
- 6 - Diameter of the collar measured in 32nds of an inch. (3/16)

Additional information relating to the numbering systems can be found in TO 1-1A-8.

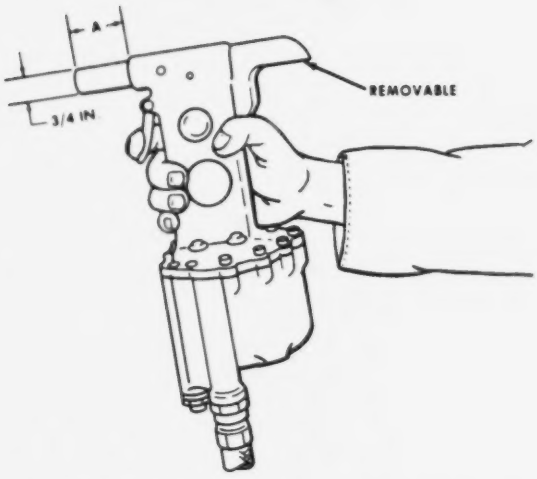
Exercises (609):

1. Name the types of lockbolt fasteners.
2. Where are the pull type lockbolts used?
3. How does a pull type lockbolt compare with an AN bolt of equal diameter?
4. In what ways do the lockbolt pins used in tension and shear differ?
5. What situation requires that the stump type lockbolt be used in place of a pull type lockbolt?
6. What material is used to fabricate stump and pull type lockbolt pins?
7. What fractional measurements are used to denote the diameter and grip length of lockbolt fasteners?
8. What type of fasteners can be replaced with steel alloy lockbolts?
9. Why are lockbolt locking collars fabricated in different colors?
10. State the parts that make up a blind lockbolt assembly.

610. Cite significant characteristics of the installation tools and preinstallation procedures used for lockbolt fasteners.

Installation tools. The installation tools that you will use to install lockbolt fasteners will be determined by the type lockbolt fastener you are installing.

a. Stump type lockbolt installation. Stump type lockbolts are installed with tools similar to those used for Hi-Shear rivets. A pneumatic riveting hammer, a bucking bar, and a swage set, equal to the diameter of the lockbolt, are the tools needed. The main dif-



BLIND	PULL	WEIGHT: 8 POUNDS					
LOCKBOLT DIA (IN.)	LOCKBOLT DIA (IN.)	STD. NOSE	A (IN.)	SHORT NOSE	A (IN.)	LONG NOSE	A (IN.)
1/4	3/16	79606	2	79616	1-3/32	79613	3-1/2
	1/4	79608	2	79618	1-3/32	79615	3-1/2

53-1676

Figure 2-8. CP 352 pneumatic rivet pull gun.

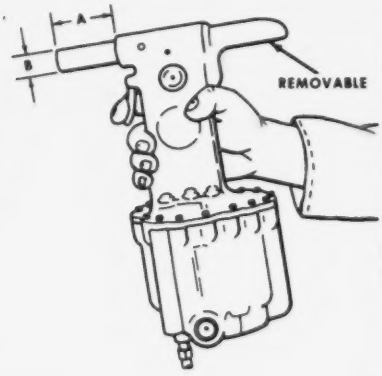
ference between these tools and the tools used to install Hi-Shear rivets is the swage set. The rivet set for Hi-Shear has an ejection port which allows the excessive material sheared off the collar during installation to be ejected. The swage set for lockbolts does not have an ejection port because the complete collar for lockbolts is swaged to the pin during installation. Swaging is the process of compressing the collar into the locking grooves of the lockbolt. No collar material is removed during this process; thus, there is no need for an ejection port on the lockbolt swage set.

b. Pull and blind types of lockbolt installation. Pull and blind types of lockbolts require the use of a pneumatic pulling gun similar to those used to install self-plugging blind rivets. The CP352 pneumatic rivet pull gun, figure 2-8, is especially designed for the rapid easy driving of aluminum lockbolts. The CP352 pneumatic rivet pull gun has a maximum pulling capacity of 2800 lbs. This tool is designed to operate at 90 psi air pressure. Every attempt should be made to furnish 90 psi of clean dry air when installing fasteners. This pulling gun will install aluminum pull type lockbolts up to 1/4 of an inch in diameter.

The CP 353 pneumatic rivet pull, figure 2-9, is similar in appearance to the CP 352, but is heavier in weight and has a pulling capacity of 5800 lbs, which is over twice that of the CP 352. This pulling gun will install 1/4 and 516th of an inch blind lockbolts and up to 1/4 of inch steel pull type lockbolts.

Preinstallation procedures. To install lockbolts, the proper grip length and correct type hole fit are required. The lockbolt grip range required for any application is determined by measuring the thickness of the material with a hook scale through the hole. The measurement is made with the parts tightly clamped together. In a situation, where the proper grip length is not available, steel or aluminum washers may be used under the head or collar to make up the required grip length. When the collar material is corrosion-resistant steel and the structure on which the washer will seat is aluminum, use aluminum washers. Use only corrosion-resistant steel washers on lockbolts with corrosion-resistant steel or monel collars. Tables 2-1 and 2-2 list the grip ranges for the various types and sizes of lockbolts.

Holes drilled for lockbolts must produce either an interference or clearance fit, depending on TO specifications. An interference fit (close tolerance) is a hole filling fit, whereas a clearance fit is a nonhole filling fit. Holes that require an interference fit are drilled smaller than the shank diameter of the lockbolt pins, requiring that the pin be either pulled or driven into the hole before the collar is applied. Holes that produce a clearance fit are prepared larger than the shank of the lockbolt pin and the pin is completely inserted in the hole before the collar and driving tool are applied. An interference fit is obtained by using step-drilling procedures. In the case of a 3/16 of an



BLIND	PULL	WEIGHT: 11 POUNDS								
LOCKBOLT DIA. (IN.)	LOCKBOLT DIA. (IN.)	STD. NOSE	A (IN.)	B (IN.)	LONG NOSE	A (IN.)	B (IN.)	ADAPTER NOSE	A (IN.)	B (IN.)
1/4	3/16							79651	2-3/4	3/4
5/16	1/4	79582	2-11/16	1-1/16	79587	4-3/16	1-1/16	79669 87548	3-1/16 1-15 16	3/4 3/4
-	5/16	79584	2-11/16	1-1/16	79589	4-3/16	1-1/16			
-	3/8	79586	2-11/16	1-1/16	79591	4-3/16	1-1/16			

53-1677

Figure 2-9. CP 353 pneumatic rivet pull gun.

TABLE 2-1
BLIND TYPE LOCKBOLT GRIP RANGES

1/4 INCH DIAMETER			5/16 INCH DIAMETER		
GRIP NR.	GRIP RANGE		GRIP NR.	GRIP RANGE	
	MIN.	MAX.		MIN.	MAX.
1	.031	.094	2	.094	.156
2	.094	.156	3	.156	.219
3	.156	.219	4	.219	.281
4	.219	.281	5	.281	.344
5	.281	.344	6	.344	.406
6	.344	.406	7	.406	.469
7	.406	.469	8	.469	.531
8	.469	.531	9	.531	.594
9	.531	.594	10	.594	.656
10	.594	.656	11	.656	.718
11	.656	.718	12	.718	.781
12	.718	.781	13	.781	.843
13	.781	.843	14	.843	.906
14	.843	.906	15	.906	.968
15	.906	.968	16	.968	1.031
16	.968	1.031	17	1.031	1.094
17	1.031	1.094	18	1.094	1.156
18	1.094	1.156	19	1.156	1.219
19	1.156	1.219	20	1.219	1.281
20	1.219	1.281	21	1.281	1.343
21	1.281	1.343	22	1.343	1.406
22	1.343	1.406	23	1.406	1.469
23	1.406	1.469	24	1.460	1.531
24	1.469	1.531			
25	1.531	1.594			

53-1671

TABLE 2-2
PULL & STUMP TYPE LOCKBOLT GRIP RANGES

GRIP NR.	GRIP RANGE		GRIP NR.	GRIP RANGE	
	Min.	Max.		Min.	Max.
1	.031	.094	17	1.031	1.094
2	.094	.156	18	1.094	1.156
3	.156	.219	19	1.156	1.219
4	.219	.281	20	1.219	1.281
5	.281	.344	21	1.281	1.344
6	.344	.406	22	1.344	1.406
7	.406	.469	23	1.406	1.469
8	.469	.531	24	1.469	1.531
9	.531	.594	25	1.531	1.594
10	.594	.656	26	1.594	1.656
11	.656	.718	27	1.656	1.718
12	.718	.781	28	1.718	1.781
13	.781	.843	29	1.781	1.843
14	.843	.906	30	1.843	1.906
15	.906	.968	31	1.906	1.968
16	.968	1.031	32	1.968	2.031
			33	2.031	2.094

53-1672

inch lockbolt pin requiring an interference fit, the pilot hole size is a #18 (.1695) twist drill and the final twist drill size is a #13 (.185). For clearance fit, only one size twist drill is needed. Insure that proper drilling procedures are used so that you do not elongate the hole. Specific -3 TOs will usually list the proper twist drill sizes for all diameter lockbolt pins for both types of fits. Also, certain part numbers of a lockbolt pin use a letter code within the part number to identify the type of fit required for that particular lockbolt pin. A letter H would indicate an interference fit, whereas the letter N indicates a clearance fit. Pull and stump type lockbolts shall be installed in interference fit holes unless otherwise specified by an aeronautical structure engineer. Holes shall be straight and perpendicular to the surface against which the lockbolt head will nest. Holes must also be round and free of burrs.

For repair situations involving the layout of new lockbolt fastener holes, always consult the specific -3 TO of the aircraft being repaired for proper fastener spacing limitations. Generally, the minimum edge distance for lockbolts is two times the diameter plus 0.06 of an inch. Minimum spacing between protruding head lockbolts is three and one half times the diameter of the pin. For countersunk head types, the minimum spacing is four times the diameter.

Exercises (610):

1. What is the main difference between the tools used to install Hi-Shear rivets and stump type lockbolts?

2. If you are going to install 3/16 inch diameter aluminum pull type lockbolts, which pulling gun will you use?

3. If you where going to install 1/4 inch diameter oversized blind lockbolts, what pneumatic pulling gun would you select?

4. What must be done before you measure the depth of holes to determine the grip length required when using lockbolt fasteners?

5. When the material composition of the collar is corrosion-resistant steel and the parts being fastened are aluminum, what should be the material composition of washers used for adjusting the grip length of lockbolts?

6. What is meant by the term "interference fit?"

7. What is meant by the term "clearance fit?"

8. What drilling procedure is used to produce interference fits?

9. What type of fit is usually required when installing stump and pull type lockbolts?

10. How is the fit required for a particular type lockbolt indicated in the specific part number?

611. State important aspects of the procedures used to install the various types of lockbolt fasteners.

Installation of lockbolt fasteners. Once the proper grip length and hole size are prepared, the lockbolt fasteners are ready for installation. Different installation procedures and sequences are required for each type of lockbolt fastener and are discussed in the following paragraphs.

a. Installation of stump-type lockbolts. Stump-type lockbolts can be installed from either side of the work depending upon accessibility, the shape of the part, and the rigidity of the part. The following steps are directed toward the procedures used to install a stump lockbolt from the collar side. Refer to figure 2-10, during the discussion of the following:

Step 1. Insert the stump pin into the prepared hole. If an interference fit is required, drive the stump pin into the hole with a hammer. Recheck the grip length at this point. Only the tapered portion of the pin should be extending through the material. The straight portion of the pin should be equal to the material thickness.

Step 2. Apply the collar to the grooved end of the pin.

Step 3. Place the bucking bar against the head of pin. Be sure that the sheets are clamped firmly together to avoid sheet separation.

Step 4. Place the swaging set over the collar, aligning it to the pin.

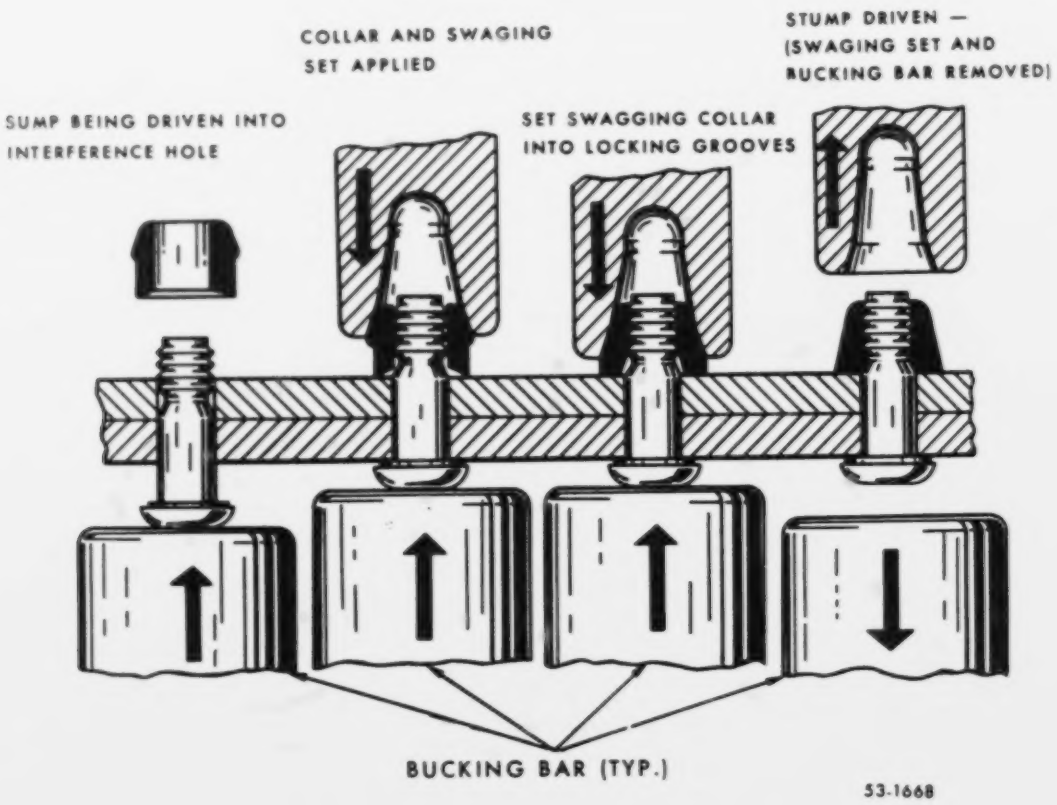

COLLAR AND SWAGING SET APPLIED
STUMP DRIVEN — (SWAGING SET AND BUCKING BAR REMOVED)
SUMP BEING DRIVEN INTO INTERFERENCE HOLE
SET SWAGGING COLLAR INTO LOCKING GROOVES
BUCKING BAR (TYP.)
53-1668

Figure 2-10. Stump lockbolt installation sequence.

NOTE: Be careful to insure that the collar is installed with the compression head away from the sheet before applying the swaging set.

Step 5. Apply a driving pressure until the collar is forced into the locking grooves of the extended pin shank.

Step 6. Hold the swaging set and rivet gun 90° to the face of the work. Continue to apply pressure until the head is full formed.

Step 7. Once the collar is formed, remove the swaging set from the collar and inspect the formation of the collar. The end of pin must be either flush or protrude not more than allowed by TO specifications above the end of the collar.

NOTE: Lockbolt stump collars can be driven on a surface not exceeding 7° from a perpendicular with the axis of the hole. The manufactured head *must* be driven on a surface perpendicular with the axis of the hole. Spot-face techniques are required for other situations.

b. Installation of pull-type lockbolts. (Refer to fig. 2-11.) The installation of the pull-type lockbolts is automatic as you will see in the following sequence:

Step 1. Insert the pin into the hole from one side of the work. Depending on the type hole fit the pin may be either fully inserted into the hole or the manufactured head may protrude above the surface, as shown in figure 2-11.

Step 2. Place the locking collar over the extending lockbolt pin.

Step 3. Apply the pulling gun, holding the collar firmly against the work. The chuck jaws automatically engage the pulling grooves of the projecting pin tail.

Step 4. Pull the trigger of the pulling gun, while firmly holding the nose assembly against the collar. The initial pull of the gun on the pin pulls the sheets between the collar and head of the pin together. And at the same time, the pin is drawn into a press fit in the hole when an interference fit is required. As the pull on the pin increases, the anvil of the pulling gun is drawn over the collar, swaging the collar into the locking grooves of the pin to form a rigid permanent lock. Continued build-up of force on the pin automatically breaks the lockbolt pin at the breakneck groove.

Step 5. Once the lockbolt pin breaks, remove the pulling gun from the collar area and inspect the formation of the collar. The lockbolt collar should be swaged throughout the length of the collar. If the bead on the collar has been fully swaged, the collar is driven okay.

c. Blind-type lockbolt installation. The installation of the blind-type lockbolt is basically the same as that for the pull type lockbolt. Blind-type lockbolts are not to be used in places where the back-side sheet is 0.020 of an inch or less. Always consult the specific -3 TO for installation specifications before installing blind-type lockbolts.

d. Special installation situation. When lockbolts are to be installed in parts which have had sealant applied to their faying surface you should remember the following:

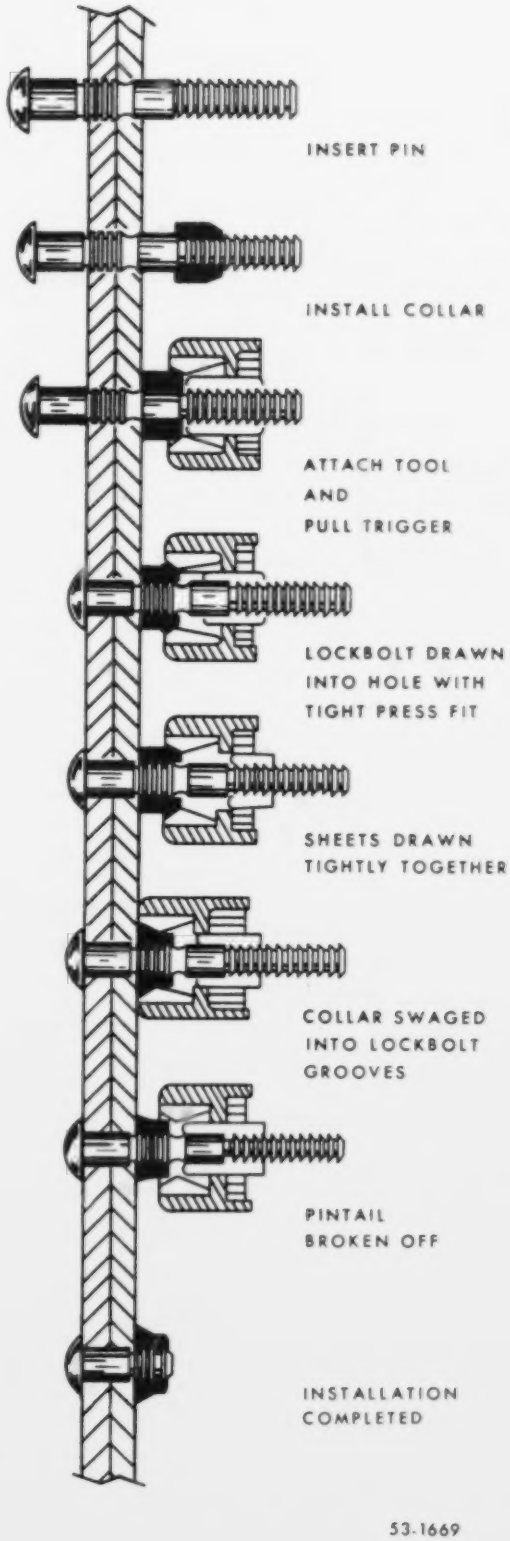


Figure 2-11. Pull-type lockbolt installation sequence.

a. When sealant is used, apply temporary fasteners (Clecos) in every other hole to obtain proper sealant squeeze out.

b. All lockbolts shall be installed before the sealant cures.

c. Clean exposed shank of the lockbolt and the surface around the hole with a clean dry rag to remove all sealant after the pin is inserted. All sealant shall be removed from the locking grooves of the pin.

d. Use clean collar only (sealant free).

NOTE: All lockbolts are lubricated and must not be degreased (MEK) if proper driving characteristics are to be maintained.

Exercises (611):

1. After inserting a stump lockbolt into a hole, what portion of the pin should not extend beyond the backside of the hole?

2. Why is it necessary to insure that sheets being fastened with lockbolts be tightly clamped prior to installing the fastener?

3. How can you tell that the locking collar used with stump and pull type lockbolts is installed backwards prior to installation?

4. After you have installed a stump type lockbolt, how should the end of the pin be in relation to the top of the collar?

5. When inspecting an installed pull type lockbolt, how can you tell that the collar is driven correctly?

6. How thick must the backside sheet be before you can install a blind type lockbolt?

7. How is proper sealant squeeze-out insured when installing lockbolts in parts which have had sealant applied to their faying surfaces?

8. Why isn't MEK solvent used to remove sealant residue from lockbolt pin, prior to installing the locking collar?

9. When is it necessary to spotface the area under the head of stump and pull lockbolts?

10. When is it necessary to spotface the area under the collar of stump and pull lockbolts?

612. Cite factors related to the inspection and the removal of installed lockbolt fasteners.

Inspection criteria. Except for the blind-type lockbolts, both the manufactured head and the shop head of the stump and pull type lockbolts can be inspected for proper installation requirements.

a. Manufactured head. The installation of flush head lockbolts on aerodynamic surfaces must conform to flush requirements of the area where they are installed. Flush head lockbolts installed on non-aerodynamic surfaces shall be within 0.015 of an inch above surface to 0.006 below the surface. Shaving of steel lockbolt flush head rivets to meet flush requirements is not permitted. Flush head aluminum alloy lockbolts may be shaved to meet flushness requirements, provided the head protrusion after shaving meets the following limitations:

Diameter	*Max. Head Protrusion*
5/32	*0.009*
3/16	*0.011*
1/4	*0.015*

Gaps between the hole surface and the flush head lockbolt are permitted provided that the gap falls within TO specifications, and provided that at least 60 percent of the fastener head is in bearing with the countersunk or dimpled hole. For protruding head lockbolts, gaps between the fastener head and the surface are limited to 0.002 to 0.006 of an inch, based on the diameter of the lockbolt, when measured at the fastener shank. Also a portion of the protruding head lockbolt must be in contact with the skin surface. Gaps between the faying surfaces of parts fastened with lockbolts shall not exceed 5 percent of the thickness of the thinnest fastened part when measured at the shank of the fastener. No more than two adjacent fasteners shall have the maximum permissible gap, and in no case shall the maximum gap exceed 0.015. Figure 2-12, illustrates procedures used to check for gap limitations.

b. Shop head. Special "go — no go" gages are used to check the installation of lockbolt collars. The type of gage and procedures are spelled out in the specific -3 TO. Visible inspection consists of checking the surface of the collar for cracks and folds. The collar

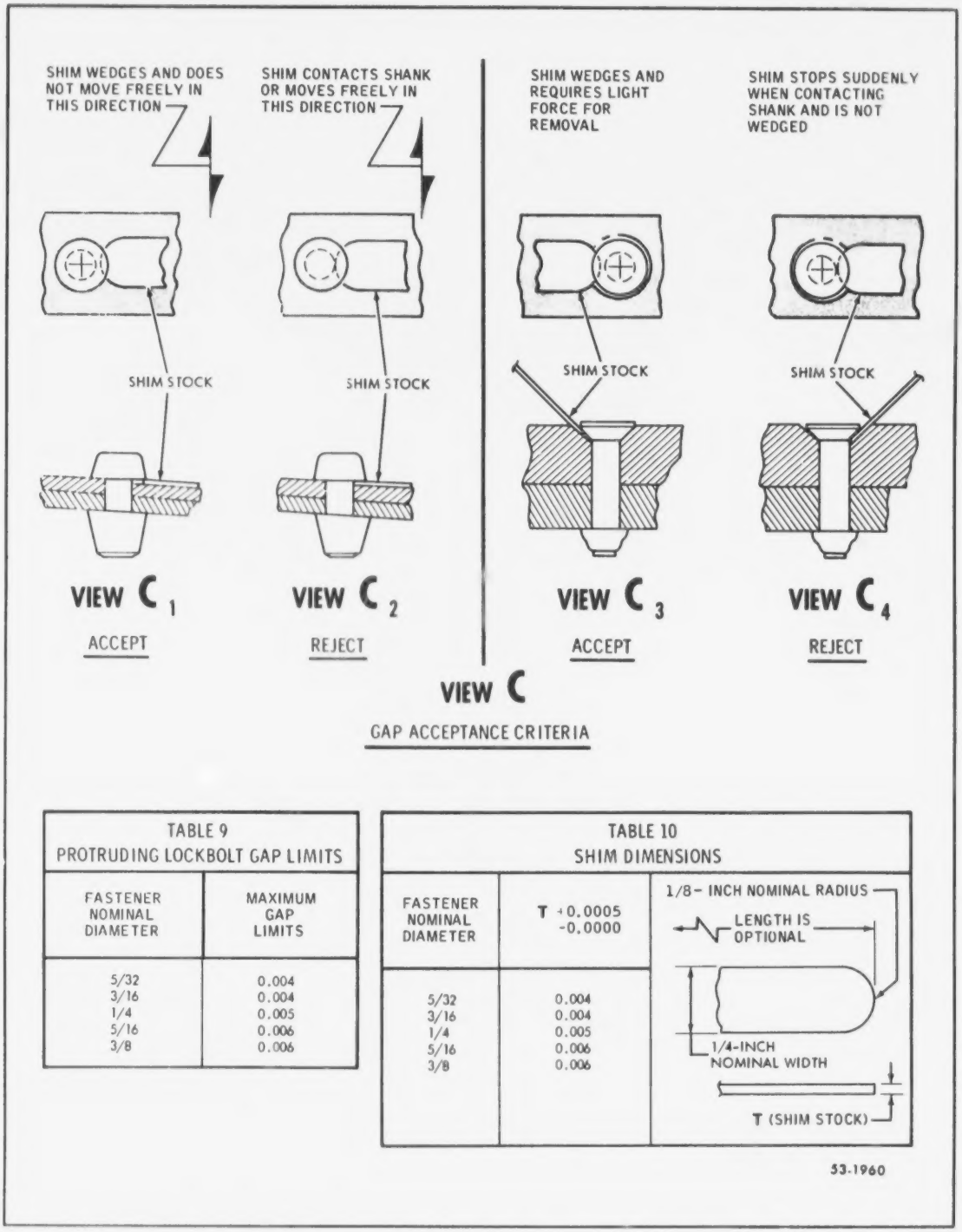


TABLE 9
PROTRUDING LOCKBOLT GAP LIMITS

FASTENER NOMINAL DIAMETER	MAXIMUM GAP LIMITS
5/32	0.004
3/16	0.004
1/4	0.005
5/16	0.006
3/8	0.006

TABLE 10
SHIM DIMENSIONS

FASTENER NOMINAL DIAMETER	T +0.0005 -0.0000
5/32	0.004
3/16	0.004
1/4	0.005
5/16	0.006
3/8	0.006

53-1960

Figure 2-12. Lockbolt inspection procedures.

TABLE 2-3
LOCKBOLT PIN PROTRUSION LIMITS

Pin Diameter	Tolerance Below		Above
3/16	.079	to	.032
1/4	.079	to	.050
5/16	.079	to	.050
3/8	.079	to	.060

53-1670

shall be swayed tightly to the pin and to the sheet. The pin break shall be flush with the collar or with the limits specified in Table 2-3.

Removal procedures. Driven lockbolts may be removed by spliting the collar with a chisel and driving the pin out of the material with a drift pin and hammer, as shown in figure 2-13. If the sheets are thin or nonrigid, use a bucking bar to support the opposite side of the collar during the removal operations. Use extra caution not to damage the hole and the surrounding surfaces. Special sleeve cutters are available and should be used in place of the chisel method when space and accessibility permit. The conventional method of drilling off the manufactured head is more difficult, but may be used when the collar is not easily accessible. Drill through the head with a twist drill the same size as the pin shank diameter, making sure the twist drill is centered. Drill to the junction of the head and then use a drift punch and hammer to remove the pin.

Where removal is necessary, another lockbolt of the same diameter may be used as a replacement since the hole is enlarged only slightly. It is possible to make several replacements in the same hole and still maintain an interference fit. Lockbolt pins which have been driven out shall not be reused.

Exercises (612):

1. What factor determines the flushness requirements of flush head lockbolt?

2. Which type of lockbolt are you allowed to shave to meet flushness requirements?

3. How much of a flush head lockbolt must be in contact with the surface before gaps are permitted?

4. What factors determine the gap permitted between the head of a protruding head lockbolt and the surface of the material?

5. What factor determines the gap permitted between the parts fastened with lockbolt fasteners?

6. When is it necessary to remove stump and pull lockbolts by drilling off the manufactured head?

7. What size twist drill should be used to remove lockbolts?

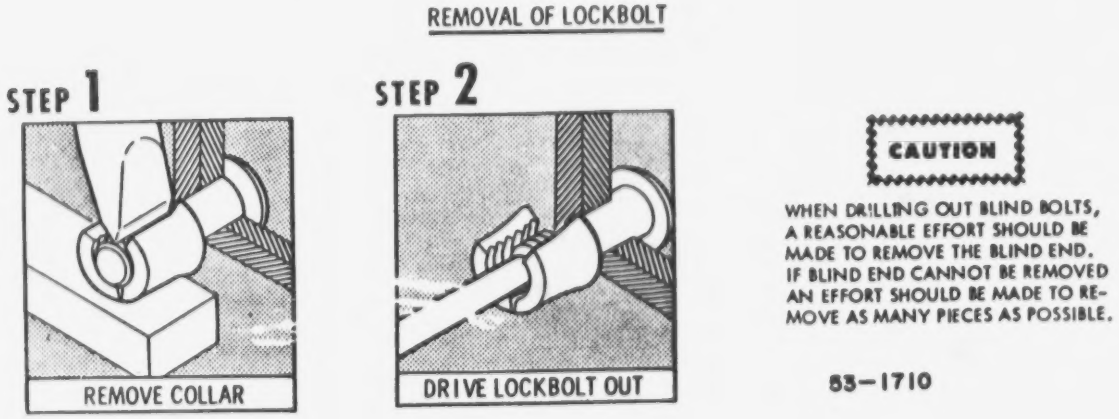

REMOVAL OF LOCKBOLT
STEP 1
REMOVE COLLAR
STEP 2
DRIVE LOCKBOLT OUT
CAUTION
WHEN DRILLING OUT BLIND BOLTS, A REASONABLE EFFORT SHOULD BE MADE TO REMOVE THE BLIND END. IF BLIND END CANNOT BE REMOVED AN EFFORT SHOULD BE MADE TO REMOVE AS MANY PIECES AS POSSIBLE.
53-1710

Figure 2-13. Lockbolt removal procedures.

8. When is it not permitted to reuse lockbolt stump pins?

9. When using the chisel method to remove stump and pull type lockbolts, when is it necessary to use a bucking bar?

10. What is the maximum gap permitted between parts fastened with lockbolts?

613. Give the principal features of Hi-Lok fasteners and their principal uses.

Hi-Lok Fasteners. The previous two fasteners, the Hi-Shear and lockbolt, were held in place by the use of a collar which was swaged to the fastener pin. Hi-Lok fasteners require a collar also, but it is attached to the pin by the use of threads. This eliminates the need for pneumatic hammers, bucking bars, and special pneumatic pull guns. The principal features of Hi-Lok are discussed in detail in the following paragraphs, so that you will be able to identify and select the correct Hi-Lok fastener for installation.

Hi-Lok fasteners are basically threaded fasteners which combine the best features of rivets and bolts; they consist of a threaded pin and a threaded collar, as shown in figure 2-14. The Hi-Lok has the feature to maintain consistently the same preload as the other fasteners in the same joint. The threaded pin is designed in two basic head styles. For shear applications, the pin is made in the lightweight, "Hi-Shear" countersunk style and in a compact protruding head style. For tension applications, the AN509 countersunk and regular protruding head styles are available. The threaded end of the Hi-Lok contains a hexagon shaped recess which engages an allen wrench which prevents rotations of the Hi-Lok pin while the collar is being installed.

The self-lock, threaded Hi-Lok collar has an internal counterbore at the base to accommodate variations in material thickness. At the opposite end of the collar is a wrenching device which is torqued by the driving tool until it shears off during installation. This shear-off point occurs when a predetermined preload or clam-up is attained in the fastener during installation. Because of the collar break-off at a designed preload, torque inspection after installation is eliminated.

Identification. Hi-Loks are identified by a standard code number which represents the type, the style of Hi-Lok, the diameter, and the grip range. The lower section of figure 2-14 illustrates the breakdown of the part numbers for the Hi-Lok pin and collar. A single part number is also used for both the pin and collar as illustrated in the following example:

Part Number—HL180-8-12
Breakdown

HL = Designation for Hi-Lok fasteners
18 = Basic pin part number
70 = Basic collar part number
-8 = Indicates the diameter of the pin measured in 1/32nds of an inch. (8/32" or 1/4" diameter).
-12 = Indicates the grip length of the pin measured in 1/16ths of an inch. (12/16" or 3/4" grip length).

Certain types of Hi-Lok collars are available with washers attached to the bottom section of the collar. The thickness of the washer is usually 0.010 of an inch. Collar with a washer thickness of 0.020 of an inch are also available. The letter W is added to the part number of the collar to indicate a washer is attached. Example—HL70 (without washer; HL70W (washer attached). When Hi-Lok fasteners are installed on tapered surfaces, self-aligning washer-collar assemblies must be used. These washer-collar combinations will accommodate a maximum tape of 8°.

The Hi-Lok pins are available in aluminum alloy (7075-T6), titanium alloy, and corrosion resistant steel. The aluminum alloy Hi-Lok fasteners have higher shear and tension strengths than DD rivets. Titanium alloy Hi-Lok fasteners are used in applications where temperatures are below 600° F. Corrosion resistant steel Hi-Lok fasteners are used in applications where temperatures range from 600° to 1200° F. Letters and numbers stamped on the head of a Hi-Lok pin indicate the basic Hi-Lok pin type and the material composition. Specific -3 TOs will contain a listing of the different head markings and their meanings. The materials used in the composition of Hi-Lok collars are identified by color codes as follows:

Material Composition	*Color Code*
2024 T6	Red
2024 T6	Black (1/32" oversized)
Stainless Steels	Cadmium or silver slated in color
Inconel	Silver plated

It is very important that the proper Hi-Lok collar be used with the type head style (shear or tension) pin to maintain a proper design balance between the pin and collar. In general, the following pin-collar combinations are acceptable:

a. Use aluminum collars (such as HL79 or HL70) with shear head pins made from material such as alloy steel, 7075-T6 or titanium.

b. In some cases, low torque-off type steel collars (such as HL94) are used with shear head pins.

c. Where tensile strength is a factor, use high torque-off type steel collars (such as HL86) with tension head pins.

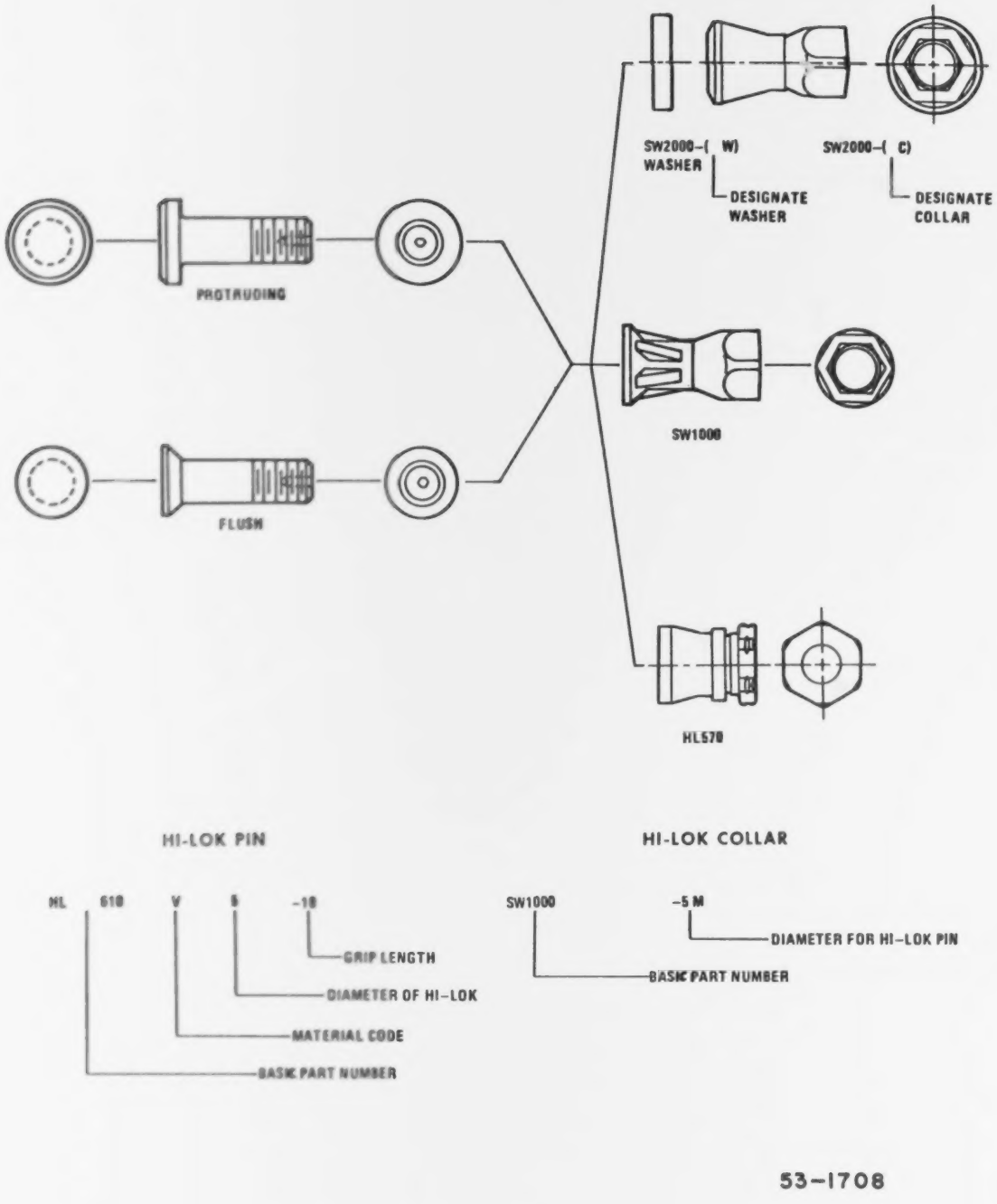


Figure 2-14. Hi-Lok fastener.

Exercises (613):

1. Hi-Lok fasteners combine the best features of what type fasteners?

2. In what areas are AN509 type countersunk Hi-Lok fasteners installed?

3. What is the purpose of the hexagon shaped recess in the bottom of Hi-Lok pins?

4. Why isn't it necessary to perform a torque inspection after installing Hi-Lok fasteners?

5. If the letter W appears in the part number for a Hi-Lok collar, what does this indicate?

6. Hi-Lok pins are available in what material compositions?

7. What must be used when Hi-Lok fasteners are installed on tapered surfaces?

8. If the temperature of a certain area of an aircraft exceeds 600° F., what should be the material composition of a Hi-Lok fastener used in this area be?

9. If you were installing an oversized aluminum Hi-Lok, what should the color of the locking collar be?

10. Where tensile strength is a factor, what type of Hi-Lok locking collar should you use?

614. Supply the informational details related to the installation of Hi-Lok fasteners.

Preinstallation factors. Before you can install Hi-Lok fasteners you must consider certain factors which will enable you to insure that the fastener will be installed correctly. Hardware selection, fastener spacing allowances, and hole preparation procedures are key factors you must consider.

a. Hardware selection. The very first steps in selecting a Hi-Lok fastener for installation is to determine the diameter and grip length required. The diameter and grip length required are directly related to the material thickness of the parts being fastened. When you determine the grip length, the material must be tightly clamped together. Step 1, figure 2-15, illustrates the method used to determine the grip length. The unthreaded portion of the pin should be equal to or not more than 0.625 of an inch greater than the thickness of the parts. The pin protrusion (threaded portion of the pin) limits are given in the lower right hand corner of figure 2-15. The correct pin protrusion is necessary so that the locking collar will be installed properly.

The material thickness can vary 1/16 of an inch from the unthreaded portion of the pin, without your selecting a different length pin. Adjustment for variations in material thickness in between the grip length of 1/16 of an inch graduations, is automatically made by the counterbore in the collar.

NOTE: Some manufacturers of Hi-Lok fasteners indicate the grip length in 1/32 of an inch. For correct measurements always consult the specific -3 TO for the aircraft being repaired.

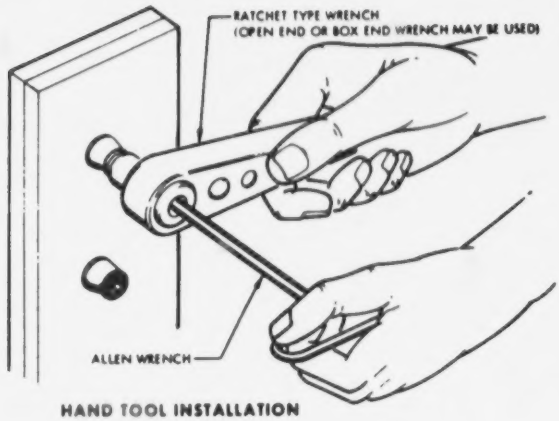
AN960 series washers may be used under the Hi-Lok collar to meet pin protrusion limits, in accordance with the following:

- The maximum total washer thickness shall be 0.032 of an inch and the maximum number of washers used shall be one, except when 0.016 of inch thick washers are used; then two may be used.
- Only corrosion resistant steel washers (AN4960C) shall be used on Hi-Lok pins with corrosion resistant steel collars.
- When the collar material is corrosion resistant steel and the structure on which the washer will seat is aluminum, use aluminum washers (AN490D).
- Only aluminum washers (AN490D) shall be used on pins with aluminum collars.

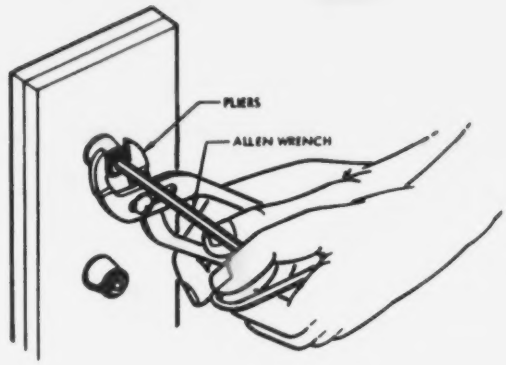
b. Fastener spacing. When repairs require the installation of a Hi-Lok fastener, follow the guidelines given in the specific -3 TO. The spacing allowance will depend on the head style of the Hi-Lok fastener being installed. Generally, the following guidelines are used.

- The minimum edge distance for flush and protruding head Hi-Lok pins is two times the diameter of the Hi-Lok pin being installed plus 0.05 of an inch.
- The spacing for Hi-Loks is measured between the centerlines of the adjacent Hi-Loks. The minimum spacing between protruding head Hi-Loks shall not be less than three and one half times the diameter of the Hi-Lok pin. The minimum spacing between flush head Hi-Loks shall not be less than four times the diameter of the Hi-Lok pin.

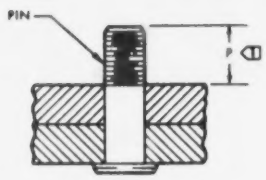
c. Hole preparation. Holes prepared for Hi-Lok



HAND TOOL INSTALLATION

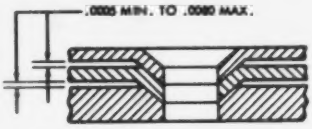


HAND TOOL REMOVAL

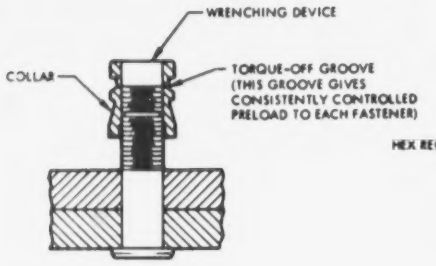


STEP 1

INSERT THE PIN INTO THE HOLE AND CHECK FOR PROPER LENGTH & PROTRUSION.

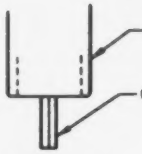


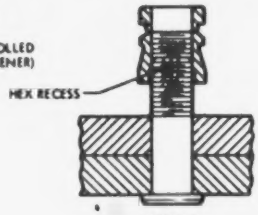
SEATING OF DIMPLES



STEP 2

MANUALLY SCREW THE COLLAR ONTO THE PIN A MINIMUM OF 3/4 OF A TURN.

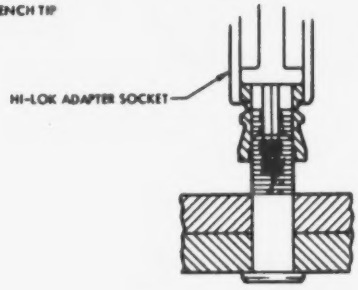




STEP 3

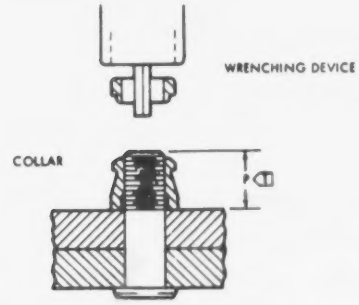
INSERT THE HEX WRENCH TIP OF THE DRIVER INTO THE PIN'S HEX RECESS.

DURING INSTALLATION



STEP 4

FIRMLY PRESS THE POWER DRIVER AGAINST THE COLLAR, OPERATE THE POWER DRIVER UNTIL THE COLLAR'S WRENCHING DEVICE HAS BEEN TORQUED-OFF.



STEP 5

COMPLETED INSTALLATION

FASTENER SIZE	(1) PIN PROTRUSION LIMITS			
	1/16 STANDARD GRIP LENGTH		2/32 STANDARD GRIP LENGTH	
	MINIMUM P	MAXIMUM P	MINIMUM P	MAXIMUM P
-5 (5/32)	.302	.384	.347	.437
-6 (3/16)	.315	.397	.360	.450
-8 (1/4)	.385	.467	.435	.525
-10 (5/16)	.490	.572	.560	.630
-12 (3/8)	.539	.617	.580	.670

Note

(1) PIN PROTRUSION LIMITS MAY BE USED AS A GUIDE IN STEP 1, BUT WILL BE USED AS ACCEPTANCE OR REJECTION LIMITS IN STEP 5.

Figure 2-15. Hi-Lok fastener data sheet.

fasteners are drilled to produce either an interference fit or a clearance fit. Some TOs refer to the interference fit as a class one fit and the clearance fit as a class two fit. It is recommended that the maximum interference fit shall not exceed .002 of an inch to avoid building up excessive internal stresses in the work piece adjacent to the hole. Twist drill sizes and hole clearance requirements are contained in specific -3 TOs.

Whether a countersunk Hi-Lok fastener is a tension or shear type will determine the countersunk limitations. As was mentioned earlier, the head designs are different and you must know the type of Hi-Lok fastener being installed, so that you can countersink the material properly. Also, the inside edge of the countersunk hole requires a slight radius. This is necessary because of the slight radius (fillet) under the head of both countersunk and protruding head Hi-Loks. The fatigue life of the Hi-Lok fasteners is increased through the use of this radius, plus this also permits the head to be fully seated in the hole. A 3/16 of an inch diameter protruding head Hi-Lok requires a .015/.025 radius, and the 3/16 countersunk head requires a .025/.030 radius.

The installation of flush head Hi-Lok pins on aerodynamic surfaces shall conform to flush requirements of the area where they are installed. Flush head Hi-Lok pins installed on nonaerodynamic surfaces shall be within 0.015 of an inch above to 0.006 of an inch below the surface. Shaving of steel fasteners heads to meet flush requirements is not permitted.

Installation procedures. The tools used to install Hi-Lok fasteners are available in both hand and power operated styles. Hand operated installation tools usually consist of a ratchet wrench, with a socket which matches the outside diameter of the locking collar, and an allen wrench. The ratchet wrench must have a hole that permits the allen wrench to be inserted as shown in the upper left corner of figure 2-15. The allen wrench is extended down through the socket, into the recess in the end of the Hi-Lok pin. This setup allows the allen wrench to hold the pin in place, while the collar is torqued on the pin. Power-operated tools basically involve the same procedures except the fastener installation is quicker.

A key factor that will influence the installation of Hi-Lok fasteners is the hole fit. When installing Hi-Loks in interference fit holes, you must drive the pin through the hole until the head is seated before you install the collar. Pins may be driven by tapping the head with a plastic mallet or by driving with a light rivet gun. Under no circumstances shall Hi-Lok pins be turned or torqued into the interference holes. Hi-Loks installed in clearance fit holes, will easily fit into the holes without being forced, which allows the pin to rotate in the hole. Looking back to figure 2-15, primarily step 2, let us pick-up the installation sequence at that point.

- Once the pin is inserted, manually screw the collar on the pin. A minimum of two threads (¾ of a turn) must be engaged before torque is applied to the collar.
- Insert the hex wrench tip into the pin hex recess.
- Firmly press the installation tool against the collar and operate the power drive or ratchet wrench until the collar's wrenching device has been torqued off. Step 5, of figure 2-15, shows an installed Hi-Lok fastener.

When you install Hi-Lok pins in interference fit holes, you will not need the allen wrench to keep the pin from turning because of the tightness of the fit. After installing the Hi-Lok fasteners inspect them to insure that they meet TO specifications.

The unique sealing ability of the Hi-Lok fastener in "wet" wing structure results from the sealant contained the collar's internal counterbored recess during and after the assembly of the fastener. Procedures for installing Hi-Lok fasteners when sealant is required are as follows:

- Apply the sealant compound over the upper section of the threaded end of the Hi-Lok pin. Prior to this step, the faying surfaces of the joint were coated with a sealant and the pin was inserted in an interference fit hole.
- Start the collar onto the pin. As the collar is driven, sealant coats all the threads and fills the internal recess.
- When the Hi-Lok collar is fully driven, the sealant forms a sealing fillet around the outer base of the collar.

Exercises (614):

1. What is the main factor that directly determines the diameter and grip length of Hi-Lok fasteners?

2. What is the maximum amount of Hi-Lok protrusion required prior to installing the locking collar?

3. When is it permitted to use two washers under a Hi-Lok collar to meet pin protrusion limits?

4. What is the necessary material composition of a washer which is used when the Hi-Lok collar is corrosion resistant steel?

5. What is the minimum fastener spacing allowed between flush head Hi-Lok fasteners?

6. A class one fit is the same as _____ fit.

7. What must you know about the Hi-Lok pin before you can countersink the holes?

8. What is accomplished by Hi-Lok pins having a fillet area on the shank?

9. What installation procedures are not allowed when installing Hi-Lok fasteners?

10. How does the installation of Hi-Lok fasteners, when sealant is required, differ from the procedures used to install lockbolt fasteners when sealant is required?

615. Cite specific details of the procedures used to inspect and remove Hi-Lok fasteners.

Inspection procedures. When inspecting the manufactured head of Hi-Lok fasteners, you should check for surface contact, countersunk fit, and aerodynamic smoothness requirements. The amount of gap permitted between the Hi-Lok fastener's head and the surface will depend upon the diameter of the fastener. Figure 2-16 shows the gap limitations and the methods used to check for gap allowances for both the protruding and countersunk head styles. Flush head fasteners installed on aerodynamic surfaces shall conform to the contour requirement of the aircraft.

The shop head inspection will involve checking the pin protrusion and visually checking the physical features of the locking collar. Special gages are available for checking the amount of pin protrusion. When special gages are not available, measure the height of the pin protrusion and compare your measurement with those listed in the specific -3 TO. The collar should be free of cracks. Collars that have wrench marks or cuts, showing evidence of being reinstalled or retightened, should be replaced. Loose Hi-Lok fasteners that can be moved axially and rotated with the fingers are not acceptable and must also be replaced.

Removal procedures. Remove Hi-Lok fasteners with standard hand tools in a manner similar to that for removing a nut from a bolt. By holding the pin with an allen wrench, you can remove the collar with pliers as shown in the upper right hand corner of figure 2-15. When Hi-Lok fasteners have been pressed or tapped into interference fit holes, the fit is sufficiently tight to grip the pin and prevent it from rotating; so the use of an allen wrench can be omitted. Once the locking collar is removed, punch out the pin. Use extreme care in the removal of Hi-Lok fasteners to prevent damage to the hole and the surrounding structure.

Exercises (615):

1. What three conditions should you check when inspecting the manufactured head of installed Hi-Lok fasteners?

2. When inspecting installed Hi-Lok fasteners, what findings would require you to replace the locking collar?

3. When is it *not* necessary to use an allen wrench to hold the Hi-Lok pin during removal procedures?

4. Why should you be careful when removing Hi-Lok fasteners?

5. Besides the condition of the collar, what other item must you check when inspecting the locking area of Hi-Lok fasteners?

616. Specify the principal features and advantages of Taper-Lok fasteners.

Taper-Lok Fasteners. The previous types of high strength fasteners had many features and requirements that were similar in nature. The Taper-Lok fasteners, though having some features similar to the previous fasteners, are uniquely different in many ways and will require that you be thoroughly familiar with the procedures used to install them.

Taper-lok fasteners consist of a close tolerance tapered pin installed in a smaller precision tapered hole and held in place with a mating nut. The installation of the tapered pin into a smaller tapered hole produces a true interference fit, greatly increasing the fatigue life of the joint. Taper-Loks are used only when the fatigue benefits are essential and each Taper-Lok fastener must be closely controlled to realize these full benefits. Compared to any other shear type of high strength fastener, Taper-Loks have the greatest joint strength and superior clamping action. The torque and preload are accurately controlled as the tapered pin is pulled into the interference-fit hole

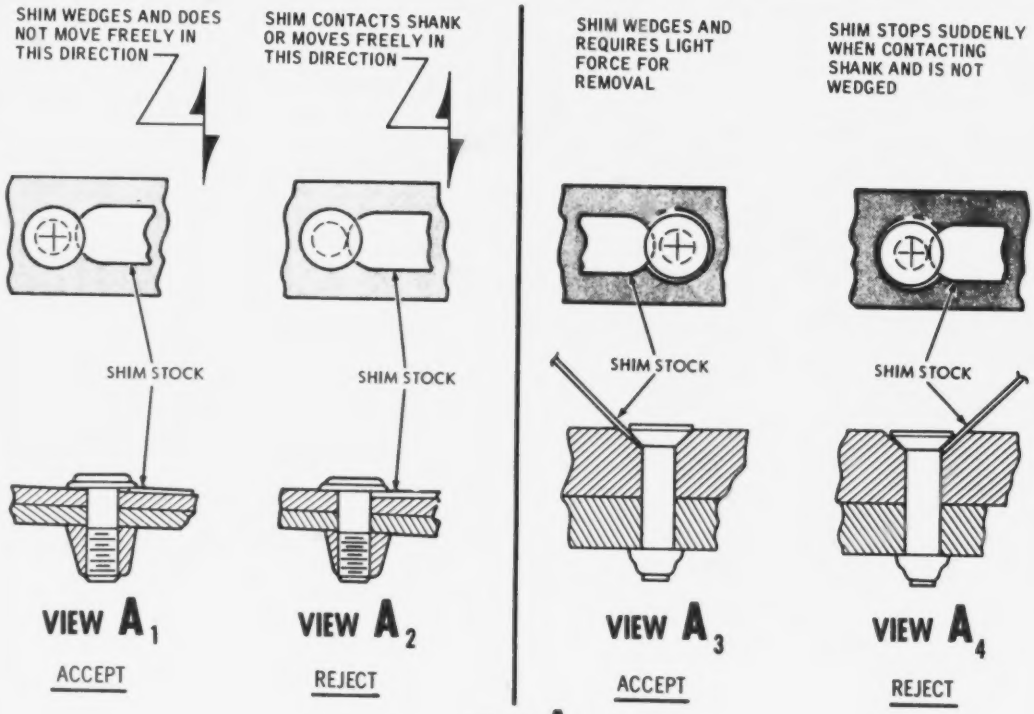


TABLE 4 – PIN PROTRUSION LIMITS	
FASTENER NOMINAL DIAMETER	P = PIN PROTRUSION (INCH)
5/32	0.302 TO 0.384
3/16	0.315 TO 0.397
1/4	0.385 TO 0.467
5/16	0.490 TO 0.572
3/8	0.535 TO 0.617

TABLE 5 – GAP LIMIT FOR ALL PROTRUDING HEAD PINS AND ALL COLLARS	
FASTENER NOMINAL DIAMETER	MAXIMUM GAP LIMITS
5/32	0.004
3/16	0.004
1/4	0.005
5/16	0.006
3/8	0.006

TABLE 6 – SHIM DIMENSIONS		
FASTENER NOMINAL DIAMETER	T +0.0005 -0.0000	1/8 INCH NOMINAL RADIUS; LENGTH IS OPTIONAL; 1/4 INCH NOMINAL WIDTH; T (SHIM STOCK)
5/32	0.004	
3/16	0.004	
1/4	0.005	
5/16	0.006	
3/8	0.006	

53-1959

Figure 2-16. Hi-Lok fastener inspection procedures.

by the lightweight mating nut through the use of a standard wrenching socket. Since even load distribution and joint integrity are assured, few fasteners can be used for a given job resulting in a greater saving of time, cost, and weight.

Taper-Lok pins. The Taper-Lok pin is slightly tapered (1/4 of an inch taper per foot) and is finished to very close tolerances. Two basic styles of Taper-Lok fasteners are in common use, the threaded nd swaged configurations. The threaded Taper-Lok fasteners use mating alloy steel or corrosion resistant steel washernuts. The lightweight low-profile styles use lightweight mating aluminum nuts. The swag-collar Taper-Lok fastener uses a mating aluminum alloy collar which is swaged into the fastener pin groove with applicable setting tools.

Both threaded and nonthreaded Taper-Lok fasteners are manufactured in several head configurations. Flush head installation can be made with shear, shear/tension, or tension type heads and with a choice of a 100° head in all types or a 60° head in the shear types. Protruding configurations include shear and tension types. With the exception of the controlled low interference series of Taper-Lok fasteners, all types are free from sockets, wrenching, or holding devices. Since the taper of the fastener is a "locking" taper, no holding devices are required.

There are two types of Taper-Lok fasteners—the standard Taper-Lok and the injection Taper-Lok. The standard Taper-Lok, figure 2-17, is used where sealant isn't required. In the channel groove of fuel tanks, injection type taper-loks, figure 2-18, are used. Injection Taper-Lok fasteners allows local fuel leaks to be resealed without removing the Taper-Lok from the hole. The sealant Taper-Lok and the standard Taper-Lok are the same except for the sealing capabilities of the sealant injection Taper-Lok.

Washernut. The washernut, lower section of figure 2-18, is a unified assembly of a washer and a free turning nut. Washernut assemblies provide automatic washer centering. In use, the washer remains stationary and allows the nut to turn freely. This feature eliminates "washer fumbling" in hard-to reach areas and does away with a washer being dropped and lost in inaccessible or critical area. A counterbore design built into the washernut assembly will absorb a maximum of .072 of excess fastener grip. When surface slopes exceed 2° but are not more than 6°, the self-aligning nut assembly is recommended. This assembly consists of self-locking, self-aligning nut and a mating self-aligning nut washer base. The upper right hand corner of figure 2-23, shows a self-aligning nut installed on a sloping surface. In general, shear nuts should be used with shear fasteners and tension nuts should be used with tension fasteners.

Assembly advantages. The tapered interference fit offers automatic self-alignment of structural members. The Taper-Lok pin is pulled into the interference fit hole. Pulling a fastener into a hole is superior to pushing or pounding as it requires less force and is less apt to damage both the fastener and the structural member. Radial compression formed by the interference fit extends the full length of the grip length for positive seating of aricraft fuel cells under both static and dynamic loading.

One distinct advantage of a Taper-Lok fastener is the fact that the pin acts as a gage for measuring the hole diameter. When the pin is placed in the hole by a firm hand pressure, simple measurements of the head protrusion above the surface, divided by 48, gives the exact interference fit between the hole and the pin.

Another distinct advantage of Taper-Lok installation is that it is impossible to install either a wrong diameter or the wrong length pin in a Taper-Lok hole. If the pin diameter is too large the threads will not come through the structure, making it impossible to install. In contrast, if the pin diameter is too small, the bolt will spin freely in the hole making installation of the nut impossible since Taper-Lok installation is dependent upon friction for holding the pin during installation. If the bolt is too long, the head will not seat when the nut is fully tightened; if it is too short, the threads will not protrude sufficiently through the structure to permit starting the nut. These readily visible installation factors provide you with a way of insuring the proper installation of every Taper-Lok bolt.

Exercises (616):

1. State the two basic types of Taper-Lok fasteners.

2. What type of Taper-Lok fastener requires the use of an aluminum washernut?

3. What head configurations are available for flush Taper-Lok fasteners?

4. What physical characteristic of a washernut permits a longer than required Taper-Lok pin to be used?

5. When is it necessary to use a self-aligning nut assembly when installing Taper-Lok fasteners?

6. Why can't the wrong diameter Taper-Lok fastener be installed?

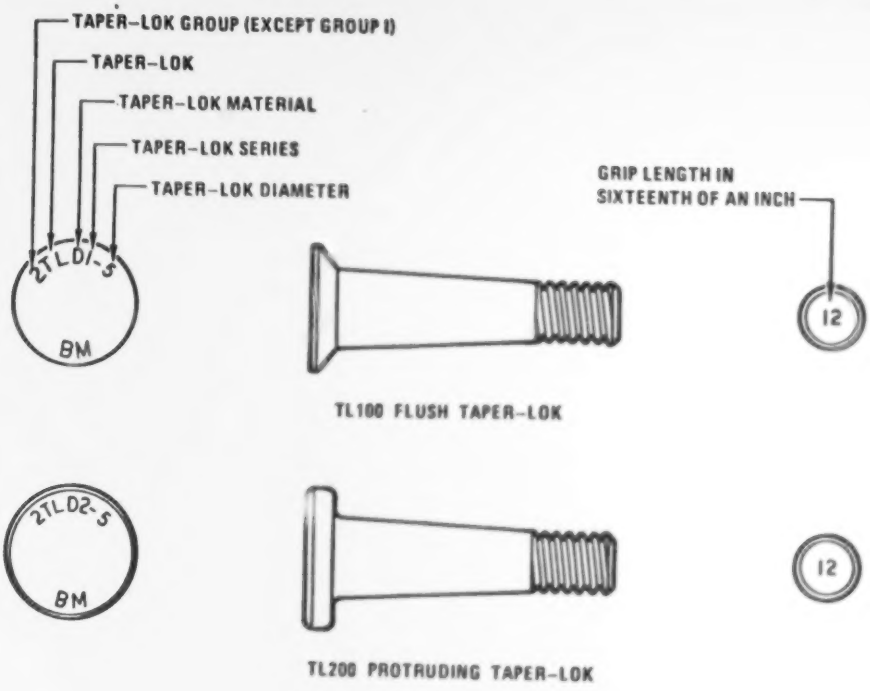


Figure 2-17. Standard type Taper-Lok fasteners.

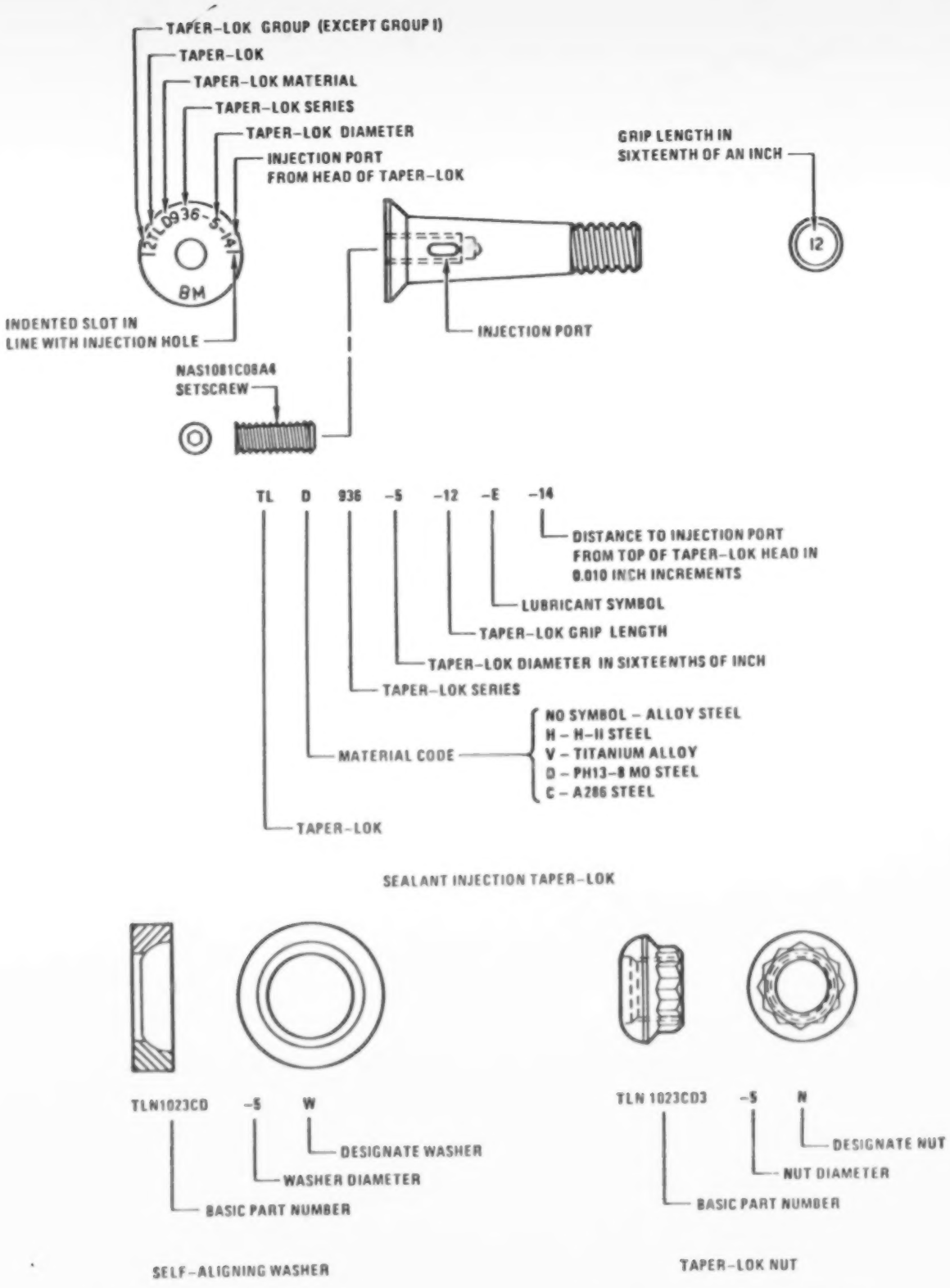


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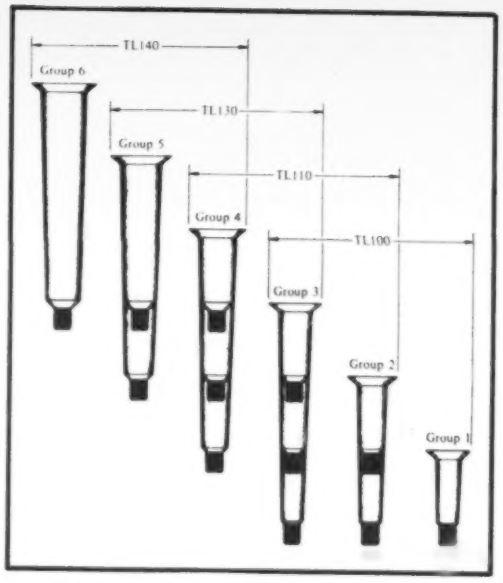
Figure 2-18. Inspection type Taper-Lok fastener.

7. What factors make it impossible to install the wrong length Taper-Lok fasteners?

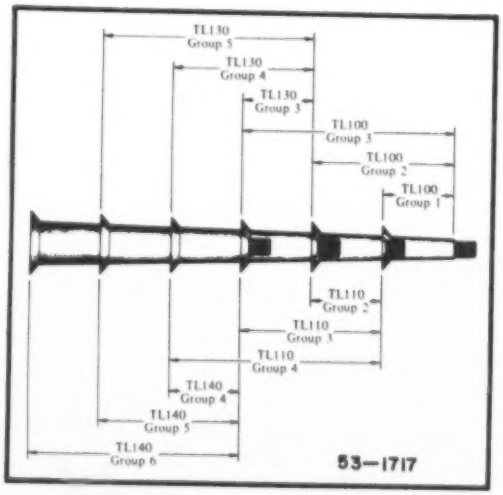
8. Why is it better to pull a fastener into a hole rather than drive or hammer a fastener into the hole?

9. What is eliminated by having the nut and washer used on a Taper-Lok fastener as one unit?

10. How does the shear strength of Taper-Lok fasteners compare with other high strength fasteners?



A. FASTNER GROUP RELATIONSHIP



B. PICTORIAL FASTNER GROUP RELATIONSHIP

Figure 2-19. Taper-Lok fastener grouping and series.

617. Point out identifying characteristics of Taper-Lok fasteners.

Grouping. Taper-Lok fasteners are divided into separate groups within a series. For any given series of Taper-Loks, there will be three different groups for each basic part number. To illustrate the relationship between the part numbers within a basic series and their relationship with the group's numbers, the Taper-Lok 100 series will be used as an example. Figure 2-19, top section, shows the complete TL 100 series. It can be seen at once that the threaded end is the basic starting point for the taper and the head becomes larger as the fastener becomes longer.

Suppose you wanted to install a TL 100 fastener in group 1. The tapered hole is first drill-reamed with the appropriate tools. When gaging the hole, suppose you discover that it was drill-reamed too large. It then becomes necessary to install a TL 100, group 2 fastener. The hole is enlarged with the appropriate group 2 drill-reamer. If this hole was enlarged excessively, it would be necessary to install the slightly larger TL 130, group 3 fastener. It follows that the TL 140, group 4, would be the next and last oversized choice available. It is important to note that the TL 100 is the basic size, the TL 110 is the single oversize, TL 130 is the double oversize, and the TL 140 is the triple oversize. Furthermore, note that the length of the fastener used determines the group number for a given part number. The lower portion of figure 2-19, shows this relationship in pictorial form. Since the large fasteners require a slightly greater torque applied to the nut to effect proper pull-up, the thread length is longer on the larger fastener.

Head marking interpretation. Typical Taper-Lok head markings are shown on figures 2-17 and 2-18 for both the standard and injection type Taper-Loks. Information given on the head of the pin tells you the Taper-Lok group and series, the material composition, and the diameter of the pin. The grip length is stamped on the bottom of the pin. The letters BM, shown on the head of the Taper-Lok in figures 2-17 and 2-18, represents the manufacturer of the Taper-Lok. In this case, Briles Manufacturing is the manufacturer. For injection type Taper-Lok fasteners, indented slots are stamped on the head of the fastener. These slots are in line with the injection ports in the shank of the pin. Also the second dash member on the head gives

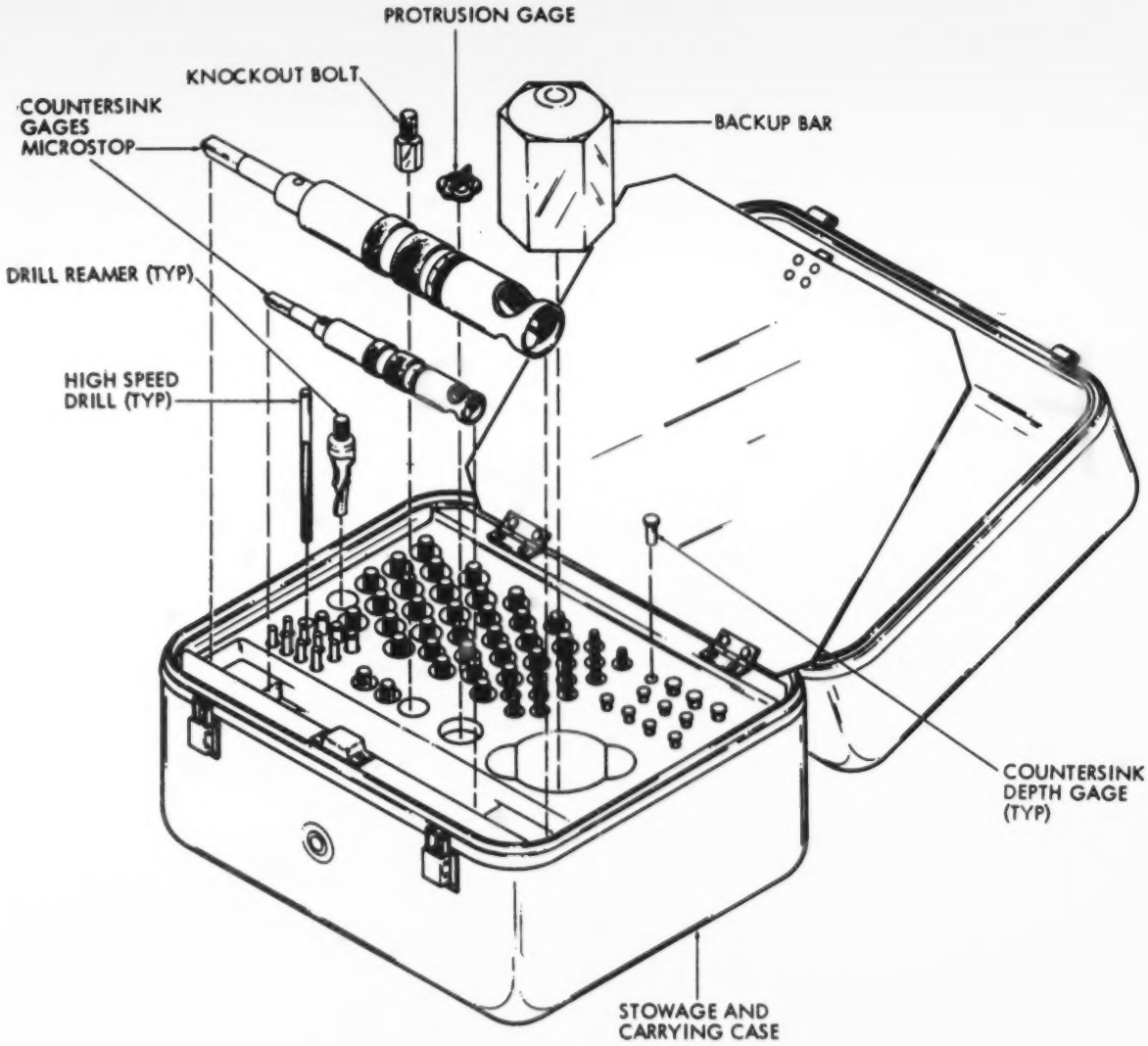


Figure 2-20. Taper-Lok installation tool kit.

the depth of the injection ports from the top of the fasteners, measured in 0.010 of an inch increments.

Part number interpretation. Shown in figures 2-17 and 2-18, are the breakdowns of part numbers for Taper-Lok pins, Taper-Lok nut and self-aligning washer. Also, the part number for the set screw for the injection Taper-Lok is shown. Take a few minutes and briefly run through the types of information found in each part number shown on figure 2-17 and 2-18.

Exercises (617):

1. How many groups of Taper-Lok fasteners are there for each basic Taper-Lok part number?

2. What type of information is denoted by the head markings on standard Taper-Lok fasteners?

3. Where is the grip length for a Taper-Lok indicated on a Taper-Lok fastener?

4. Why are indented slots placed on the head of injection type Taper-Lok fasteners?

5. If the second dash number on the head of an injection type Taper-Lok fastener were 10, what would this tell you?

618. List the type of coded information on the tools used to install Taper-Lok fasteners, and state details of the preinstallation procedures required prior to final installation of Taper-Lok fasteners.

Installation tools. It is mandatory to have a proper fit between Taper-Lok and their holes. The Taper-Lok fastener hole is the most important factor in obtaining a proper installation. With this in mind, let us take a close look at the tools used to insure that the correct sized holes are prepared.

Special installation tools, as shown in figure 2-20, are necessary to install Taper-Lok fasteners. Each tool is numbered with a code showing the type, group number, and diameter for ease of proper selection. To determine the type tools to use, check the head markings on the head of the Taper-Lok pin, and then select the applicable installation tools required. An example of the Taper-Lok drill and drill reamer code is as follows:

Example TLD 2040 A - 1 4

Breakdown

TLD 2040 - Basic tool number.

A - Tool type.

- A = Drill, c'sink combination for 100° head type bolts.
- B = Drill, radius combination for protruding head type bolts
- A = Drill, c'sink combination for 100° head type bolts.
- B = Drill, radius combination for protruding head type bolts.
- AR = Reamer, c'sink combination for 100° head type bolts.
- BR = Reamer, radius combination for protruding head type bolts.

-1 - Group number.

- Pin diameter in sixteenths of an inch.

Taper-Lok reamers. Figure 2-21 shows the various types of reamers used to install Taper-Lok fasteners. Note the drill cutting lips on the end and the reaming flutes on the sides of the combination drill-reamers showing in the upper half of figure 2-21. As the combination drill-reamer enters the material, the drilling is performed by the front two flutes. After the drill breaks through the backside of the material, the four-fluted area of the drill-reamer takes over to size (shape) the tapered hole precisely and form the countersink and fillet radius. Cutting is accomplished by the entire drill-reamer, not just the end of the drill as in straight hole drilling. The countersink, tapered hole and fillet radius are all produced in one precision efficient operation.

Greater hole diameter accuracy and smooth finishes are obtained by tapered drilling than by straight drilling. The reasons for this is that the leading edge cutting tips do not cut while the drill is being backed out of the hole because of the taper. And, also, chip galling on backout is eliminated by instant drill and chip relief. The hole is sized by the cutting margins of the drill flutes, not by the cutting tips. These tips may vary as much as 0.005 of an inch and the hole (sized by the flute margins of the drill) will still produce a precision hole.

The *micro-stop drill cage* is used for drilling-reaming to extremely accurate depths. The cage has a graduated indexing sleeve; each graduation on the sleeve increases or decreases the depth capabilities by one-one thousandth of an inch (.001) depending upon which way it is turned. The micro-stop cage is intended for use with either a drill press or a hand-held drilling unit. In hand drilling, straight feeding is assured through the use of the mircro-stop drill cage. The cage allows placement of the tubular foot against the structure being drilled before the drill touches the material. As long as the foot is held flat against the material being drilled, a straight hole is assured.

Preinstallation procedures. Before preparing a new hole for a Taper-Lok fastener, make sure the selected Taper-Lok drill-reamer will cut the proper hole by performing the following procedures on scrap material. Two holes are prepared, in this procedure, to make certain that the drill-reamer will consistently prepare acceptable holes.

a. Obtain two pieces of scrap material of the same alloy and within 0.030 of an inch of the thickness of the parts on the aircraft which need the new hole.

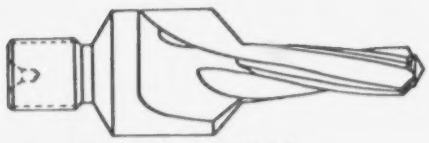
b. Clamp the two pieces of scrap together, and anchor them for drilling.

c. Select a twist drill 1/64 of an inch smaller than the diameter of the fasteners to be installed. Use the undersize drill as a pilot drill.

d. Drill two pilot holes in the scrap material, being careful to drill within 2° perpendicular to the surface.

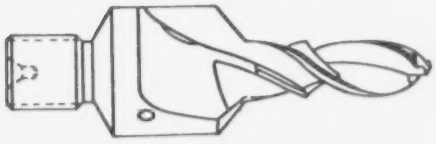
e. Drill the Taper-Lok holes, using the Taper-Lok drill-reamer, being careful to keep the drill at an angle within 2° perpendicular to the surface. Cetyle alcohol may be used as a lubricant.

f. Obtain a Taper-Lok of the proper size; apply a



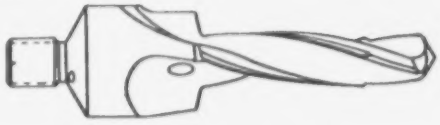
T.F.I.M. 25.0051 OR TLD7330AR
FLUSH TAPER–LOK REAMER

T.F.I.M. 25.0052 OR TLD7330BR
PROTRUDING TAPER–LOK REAMER



T.F.I.M. 25.0059 OR TLD7030A
DRILL, REAMER AND COUNTERSINK COMBINATION

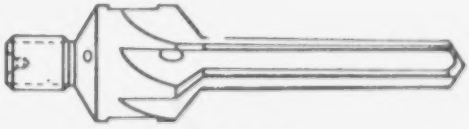
T.F.I.M. 25.0065 OR TLD7142AR
REAMER AND COUNTERSINK COMBINATION



T.F.I.M. 25.0066 OR TLD7142BR
REAMER AND RADIUS COMBINATION

T.F.I.M. 25.0055 OR TLD7310R

T.F.I.M. 25.0057 OR TLD7311R



T.F.I.M. 25.0058

HAND TAPER–LOK REAMERS

Figure 2-21. Taper-Lok drill-reamers and reamers.

light coat of Prussion Blue Oil-Color to its shank; and insert it into the hole, being careful not to turn it.

NOTE: Never insert a blueing check Taper-Lok pin in a hole without checking the hole to verify that it is clean.

g. Using an 8-ounce plastic-tipped mallet, strike the head of the fastener a medium blow.

h. Using the proper removal tool, remove the Taper-Lok, being careful not to turn it. Check the shank of the Taper-Lok for the extent of the area bearing against the hole, in both layers of the joint, and there should be a complete ring around the shank, showing the hole is not elongated.

i. Repeat the steps for the other holes in the scrap material. Use a new Taper-Lok for this hole.

j. Obtain another Taper-Lok of the proper size and insert it into one of the holes, using finger pressure only.

k. Measure the amount of head protrusion P., as shown in figure 2-22 (center fastener).

l. If the holes fail to show the proper fit, check all installation tools for wear before proceeding to install the fasteners in the repair work.

Exercises (618):

1. What is the most important factor that must be considered to obtain a properly installed Taper-Lok fastener?

2. The numbering code used on Taper-Lok installation tools tells you what type of information?

3. At what point in the drilling of Taper-Lok holes, do the fluted areas of the drill-reamer form the taper in the holes?

4. What part of the drill-reamer does the actual cutting, during the drilling operations?

5. Why is it possible to obtain greater hole accuracy and a smoother wall finish with a tapered drill, then you can obtain with a straight twist drill?

6. Scrap material selected for preinstallation of Taper-Lok fasteners should be how thick?

7. When drilling holes for Taper-Lok fasteners, you must hold the drill-reamer within _____ perpendicular to the surface.

8. Wht is the reason for using a prussion blue oil-color check when installing Taper-Lok fasteners?

9. What may you use as a drill lubricant when drilling Taper-Lok holes?

10. How much insertion pressure is applied to the head of a Taper-Lok fastener prior to measuring the amount of head protrusion?

619. Explain portions of the procedures required to install Taper-Lok fasteners.

Installation factors. Once you have verified that the installation tools you have selected are the correct ones and that the proper grip length Taper-Lok is being used, you are ready to install the fasteners. The procedures are very similar to those you used in the test strips, except that a blueing test for surface bearing is not necessary.

Rather than review the step-by-step procedures previously discussed for the test strips, we list the factors that you must follow and remember when installing Taper-Lok fasteners.

a. Always make sure the material is clamped tightly together before you drill it.

b. Select a pilot drill 1/64 of an inch smaller than the diameter of the Taper-Lok to be used, being careful to keep the drill within 2° of perpendicular to the surface.

c. When you are drill-reaming Taper-Lok holes, the pressure guiding the drill-reamer is very important. Tapered drill-reamers require a different feel from that of straight hole drilling; and they require less pressure, except when the countersunk is being formed. Feed pressure must be light but the drill motor must be held firmly. After the hole has been completed, do not let the drill turn in the material. This can cause oversized holes. As soon as the depth is reached, back the drill out immediately.

d. When properly drilled, the hole, countersink, and radius will display a bright smooth finish. The reason for this bright smooth finish is that when the drill is backed out of the hole, no cutting or scratching of the walls take place because of the taper hole.

e. Holes must be free of chips, longitudinal

scratches, rifling, and other imperfections. Every precaution must be taken to make each hole as nearly perfect as possible.

f. Cetyle alcohol may be used as a lubricant on the drill, but do not flood the hole if uncured faying surface sealant is present.

g. Clean the Taper-Lok hole with a plastic brush or cheesecloth dampened with MEK. When using cheesecloth, insert it from the lower surface and pull the cloth completely through the hole. Repeat as required, using a clean cloth for each pass through the hole.

h. After the fastener has been positioned into the hole, press the head down with finger pressure *only*. Tightening the washernut will pull the head down against the surface. The specific -3 TO will give the torque valves for each diameter fastener. Figure 2-22 illustrates the step by step procedures for installing Taper-Lok fasteners.

Sealant fasteners. When you are installing a standard type Taper-Lok which requires sealant, dip the threaded end of the Taper-Lok plus one half of the shank in the sealant and insert the Taper-Lok fastener into the hole.

Do not use high-speed drivers to tighten Taper-Loks which join parts with sealant between them. The sealant between the parts resists being displaced, and this resistance increases as the tightening speed of the fastener increases. Therefore, using high-speed drive tools could result in too low a torque being applied to the installed fasteners. A standard Taper-Lok, which has had sealant applied, should have a bead of sealant around its head and its collar after installation.

Exercises (619):

1. When drilling holes for Taper-Lok fasteners, why is it recommended that as soon as the hole is completed, you should quickly remove the drill-reamer from the hole?

2. What type of finish is produced when holes drilled for Taper-Lok fasteners are drilled properly?

3. When is it necessary to limit the amount of lubricant used when drilling Taper-Lok holes?

4. How should Taper-Lok holes be cleaned?

5. Why should high-speed drivers not be used to torque Taper-Lok fasteners when the parts being fastened have sealant between them?

6. When you inspect drilled holes for Taper-Lok fasteners, how should they look?

7. When you select a pilot drill for Taper-Lok holes, how should the diameter of the pilot drill compare to the final hole diameter?

620. Cite the factors concerned with the inspection, removal and substitution of Taper-Lok fasteners.

Inspection criteria. Since Taper-Lok fasteners are open-area fasteners, both the manufactured head and the washernut portions can be inspected after installation. Technical order specifications are very critical, as you will see in the following paragraphs.

a. Manufactured head area. The heads of flush Taper-Loks installed on the exterior surfaces of the aircraft should not protrude into the airstream more than that allowed by TO aerodynamic smoothness requirements. There should be no gaps between the heads and their countersunk holes. For flush head Taper-Loks installed on the interior surface of the aircraft, gaps between the head and their countersunk holes should not exceed 0.003 of an inch, and this 0.003 of an inch gap must not exceed more than one-third the perimeter of the fastener head. Also, the head should be checked for signs of distortion. Distortion is evidenced by the appearance of a distinct ring on the head of the fasteners.

Protruding head Taper-Loks are also inspected for gaps. A gap should not exceed 0.004 of an inch, and this gap is permissible only for one-half of the fastener head's perimeter. No more than two fasteners in any one row of fasteners can have the maximum allowable gap. Where sealant injection Taper-Loks are installed, verify that the two alignment marks on the Taper-Lok head are aligned in the direction of the sealant groove within the structure.

b. Washernut area. Examine the washernuts to determine that they are seated against the surface. Washernuts should be free of cracks and any other damage. Any washernut that is cracked or damaged must be replaced. Gaps under the washernut that permit the insertion of a 0.0015 of an inch filler gage to the shank are unacceptable. The amount that the threaded end of the Taper-Lok shank should protrude above the top of the washernut is shown in fugure 2-23. Specifications are given in specific -3 TOs as to allowable thread protrusion.

Removal procedures. Two methods of removing Taper-Lok fasteners are shown in figure 2-24. The knockout tool method, the upper portion of figure 2-24, requires the use of a specially designed removal tool. In use, this tool is screwed on the fastener after the

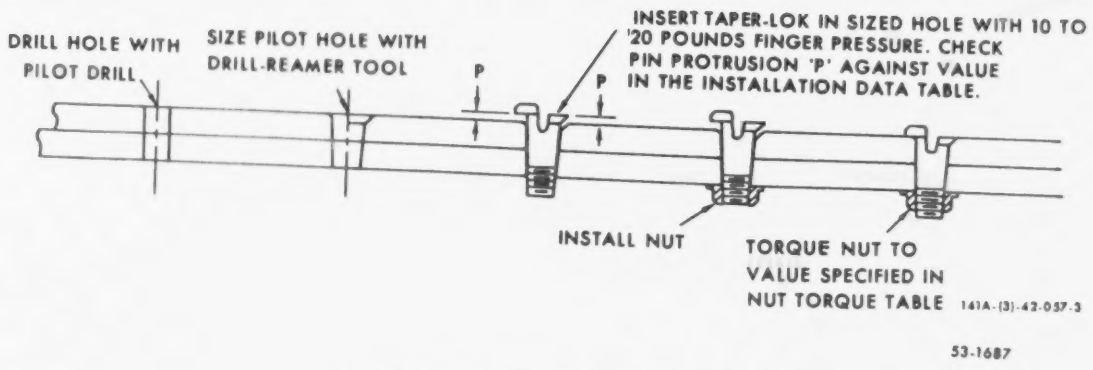

DRILL HOLE WITH PILOT DRILL
SIZE PILOT HOLE WITH DRILL-REAMER TOOL
P
P
INSERT TAPER-LOK IN SIZED HOLE WITH 10 TO 20 POUNDS FINGER PRESSURE. CHECK PIN PROTRUSION 'P' AGAINST VALUE IN THE INSTALLATION DATA TABLE.
INSTALL NUT
TORQUE NUT TO VALUE SPECIFIED IN NUT TORQUE TABLE
141A-(3)-42-057-3
53-1687

Figure 2-22. Taper-Lok installation steps.

nut is removed and then tightly taped out with a hammer. If the pin is carefully removed, and can be relubricated, it may be reused. If the pin cannot be relubricated it must be scrapped. Also the removed washer nut must be scrapped.

If the Taper-Lok cannot be removed with the knock-out tool, the C-clamp method can be used to press out the pin, as shown in the lower portion of figure 2-24. Drilling off the manufactured head and punching out the remaining portion of the pin is not possible because of the tapered hole and pin.

Substitution allowances. On a replacement basis, there is no authorized substitute fastener that is equivalent to a Taper-Lok fastener. This is because of the tapered hole that the Taper-Lok is installed in. When a Taper-Lok fastener is removed from a hole, the hole may be slightly oversize. This is caused by the plastic deformation of the material around the hole which is due to the high interference fit of the Taper-Lok pin. Acceptance of a hole which is slightly oversize for reinstallation of the removed Taper-Lok of the same size, is permitted only if the protrusion of the Taper-Lok pin is within protrusion limitations. If the hole is oversized to the extent that the Taper-Lok protrusion is less than the limits, the hole must be reworked for an oversized Taper-Lok. Approval by a structural engineer is required before increasing the oversized hole to the next basic full diameter (3/16 to 1/4 of an inch, as an example).

Exercises (620):

1. How is distortion on the head of a Taper-Lok fastener indicated?

2. Wht is the gap limitation for a flush head Taper-Lok fastener installed on the interior surface of an aircraft?

3. What is the gap limitations for protruding head Taper-Lok fasteners?

4. What is the maximum gap permitted under the washernut of Taper-Lok fasteners?

5. Beside checking the physical features and gap limitations of the washernut, what else must you check in the washernut area of an installed Taper-Lok fastener?

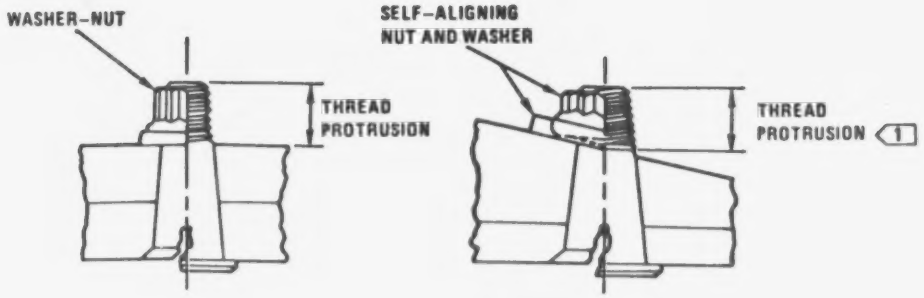
6. What factors determine if a Taper-Lok pin can be reused?

7. Why can't the conventional method of drilling off the fastener be used to remove Taper-Lok fasteners?

8. Why isn't there an authorized substitute fastener for Taper-Lok fasteners?

9. When is it possible to reinstall the removed or a new Taper-Lok pin in the same hole?

10. When is it permissible to increase the diameter of a Taper-Lok fastener to the next full size diameter?



TLV100 TLD200 TLD936 TLD100 TLV200 TLC200			TLV300 TLC300		
FASTENER DIAMETER	THREAD PROTRUSION		FASTENER DIAMETER	THREAD PROTRUSION	
	MINIMUM	MAXIMUM		MINIMUM	MAXIMUM
5/32	0.250	0.337			
3/16	0.270	0.358	3/16	0.333	0.420
1/4	0.322	0.409	1/4	0.396	0.483
5/16	0.371	0.457	5/16	0.474	0.581
3/8	0.396	0.483	3/8	0.552	0.639
7/16	0.443	0.530	7/16	0.615	0.702
1/2	0.475	0.562	1/2	0.693	0.780

LEGEND

1 THREAD PROTRUSION IS MEASURED FROM THE SURFACE OF THE WASHER, IF USED, TO THE END OF THE THREAD.

53-1685

Figure 2-23. Taper-Lok pin protrusion criteria.

2-2. Blind Area High Strength Fasteners

Just as there are blind rivets to use in place of solid shank rivets there are blind high strength fasteners to use in place of the "open" area high strength fasteners. Blind high strength fasteners are available in various styles and types. Our discussion will be directed towards the following three: the Jo-Bolt, the Hi-Shear threaded blind bolt, and the mechanical-lock blind bolt. Technical order 1-1A-8 and the specific -3 TO for the aircraft being repair should be consulted for other types of blind high strength fasteners not covered.

Since these are blind type fasteners, you must give special attention to the selection factors, hole preparation, and installation procedures. This section is designed to give you this knowledge, so that you will be able to select the proper fastener quickly and with a high degree of confidence.

621. State the principal features and explain coding of Jo-Bolt fasteners.

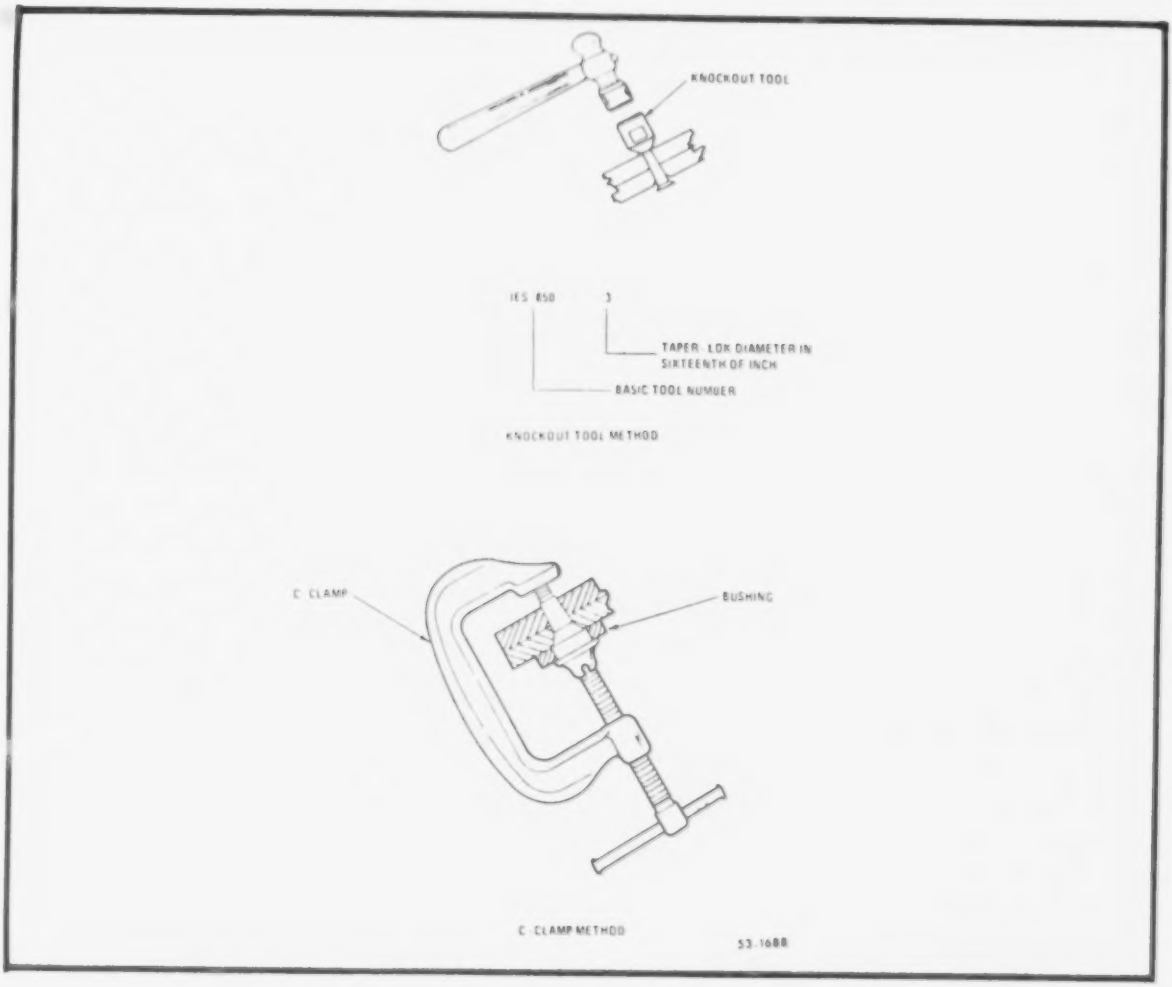


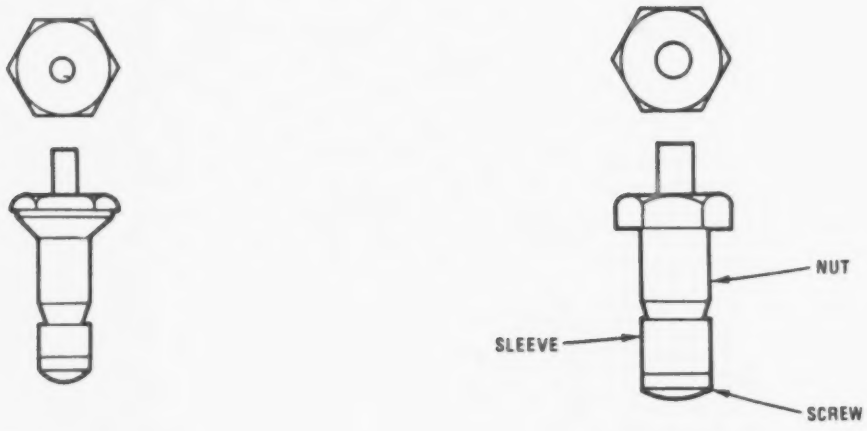
Figure 2-24. Taper-Lok removal procedures.

The Jo-Bolt. The name Jo-Bolt is a trade name for a technicliy classified, internally threaded, three-piece rivet. Because this trade name has become common language for this type of fastener, this is the term that will be used throughout the discussion.

The Jo-Bolt fastener consists of three parts: an aluminum alloy or steel nut, a threaded alloy steel bolt (screw), and a corrosion resistant steel sleeve which are factory preassembled. The relationship of each part in the complete assembly is shown in the right hand illustration of figure 2-25. As the Jo-Bolt is installed, the bolt (screw) is turned while the nut is held causing the sleeve to expand over the end of the nut, forming the blind head. When installation is complete, the bolt wrenching end breaks off.

Three types of Jo-Bolts are available: protruding (hex) head, the 100° flush head, and the millable flush head. The millable flush head Jo-Bolt, as shown in the left hand illustration in figure 2-25, has a protruding (hex) head with a 100° taper on its lower side. After installation in a countersunk hole, the protruding part of the head is milled-off. The flush type Jo-Bolts normally takes the same size countersink or dimple as required for the corresponding size MS2046 rivet. Presently, Jo-Bolts are available in five diameters: 5/32, 3/16, 1/4, 5/16, and 3/8 of an inch. Oversized Jo-Bolts of 1/64 and 1/32 of an inch in diameter are available. Jo-Bolt lengths are expressed in 1/16 of an inch increments. Special nonmagnetic Jo-Bolts are also available for use where sensitive electronic equipment is located.

The high shear and tension strength of this bolt makes it suitable for use in areas of high stresses where some of the other blind fasteners are not practical. Jo-Bolts are often a part of the permanent structure of late model aircraft. They are used in areas which are not often subjected to replacement or servicing. Jo-Bolts are sometimes used where there is insufficient clearance for the installation of other fasteners. Because it is a three part fastener, it is not used where any part, in becoming loose, could be drawn into the engine air intakes.



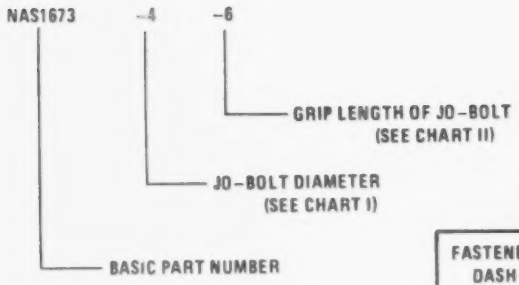


CHART I

JO-BOLT DIAMETER DASH NUMBER	JO-BOLT NOMINAL DIAMETER
-08	0.164
-3	0.200
-4	0.260

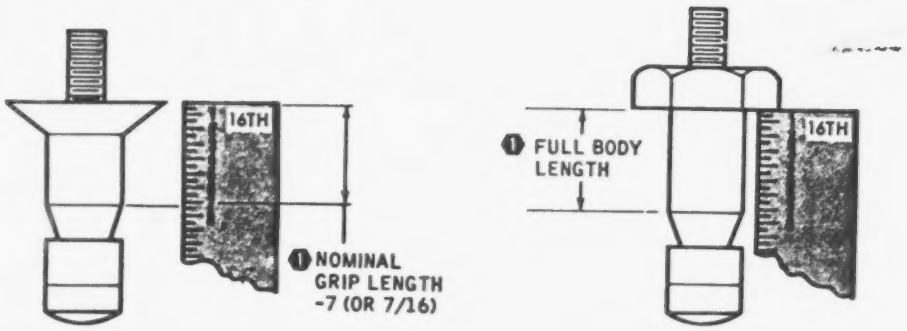
CHART II

FASTENER LENGTH DASH NUMBER	GRIP LENGTH RANGE
1	0.031 – 0.093
2	0.094 – 0.156
3	0.157 – 0.219
4	0.219 – 0.281
5	0.281 – 0.344
6	0.344 – 0.406
7	0.406 – 0.469
8	0.469 – 0.531
9	0.531 – 0.594
10	0.594 – 0.656
11	0.656 – 0.719
12	0.719 – 0.781
13	0.781 – 0.844
14	0.844 – 0.906
15	0.906 – 0.969
16	0.969 – 1.031

53-1742

Figure 2-25. Jo-Bolt identification.

Identification. Jo-Bolts are identified by a basic part number which represents the type and style of Jo-Bolt, nominal diameter, and the grip range. Figure 2-25, illustrates a breakdown of a NAS part number for a Jo-Bolt. Some manufacturer's use two dash numbers after the basic part number, whereas other manufacturers use only one dash number. In the part number PLT154-5-5, the first dash number indicates the diameter and the second dash number indicates the grip length. For a part number, such as FF6164-5, the number 164 indicates the diameter (series) and the dash number represents the grip length. The specific -3 TO will usually give a breakdown of the manufacturer's part number.



FLUSH HEAD -7 (7/16)

PROTRUDING HEAD -7 (7/16)

TABLE OF GRIP LENGTHS

GRIP DASH NO.	NOMINAL GRIP	GRIP RANGE MIN	GRIP RANGE MAX	GRIP DASH NO.	NOMINAL GRIP	GRIP RANGE MIN	GRIP RANGE MAX
2	1/8	0.094	0.156	17	1- 1/16	1.032	1.094
3	3/16	0.157	0.219	18	1- 1/8	1.095	1.156
4	1/4	0.220	0.281	19	1- 3/16	1.157	1.219
				20	1- 1/4	1.220	1.281
5	5/16	0.282	0.344	21	1- 5/16	1.282	1.344
6	3/8	0.345	0.406	22	1- 3/8	1.345	1.406
7	7/16	0.407	0.469	23	1- 7/16	1.407	1.469
8	1/2	0.470	0.531	24	1- 1/2	1.470	1.531
9	9/16	0.532	0.594	25	1- 9/16	1.532	1.594
10	5/8	0.595	0.656	26	1- 5/8	1.595	1.656
11	11/16	0.657	0.719	27	1-11/16	1.657	1.719
12	3/4	0.720	0.781	28	1- 3/4	1.720	1.781
13	13/16	0.782	0.844	29	1-13/16	1.782	1.844
14	7/8	0.845	0.906	30	1- 7/8	1.845	1.906
15	15/16	0.907	0.969	31	1-15/16	1.907	1.969
16	1	0.970	1.031	32	2	1.970	2.031

Note

1 MEASURE FULL BODY LENGTH TO NEAREST 1/16 INCH.

53-1712

Figure 2-26. Jo-Bolt measuring procedures.

Exercises (621):

1. Name the parts that make-up a Jo-Bolt assembly.

2. State the types of Jo-Bolts head styles.

3. In the manufacturer's part number PLT154-8-10, what is indicated by the -8 and the -10 numbers?

622. Cite details of the procedures followed to properly install Jo-Bolts fasteners.

Jo-Bolt installation. The proper installation of Jo-Bolt fasteners requires that you pay extra attention to grip length selection, hole preparation, and installation procedures.

a. Determining grip length. When installing replacement Jo-Bolts in previously drilled holes, the required grip length is determined by using a hook scale to measure the thickness of the parts being fastened. After you have obtained this measurement convert it to the nearest 1/26 of an inch. This conversion is necessary because the grip length of Jo-Bolt is measured in 1/16 of an inch. Next, it is just a matter of selecting the Jo-Bolt closest to your measurements. Figure 2-26. illustrates the correct procedures to use when measuring both head styles of Jo-Bolts. You should measure the full length of the Jo-Bolt to the nearest 1/16 of an inch.

In work situations where you know the thickness of the part being fastened all you need to do is consult a grip length table, like the one shown in figure 2-26, minimum and maximum grip range is usually given. The grip length of the Jo-Bolt selected must not exceed the material thickness being attached by more than 1/16 of an inch. While the grip length measurement indicates borderline case between two grip

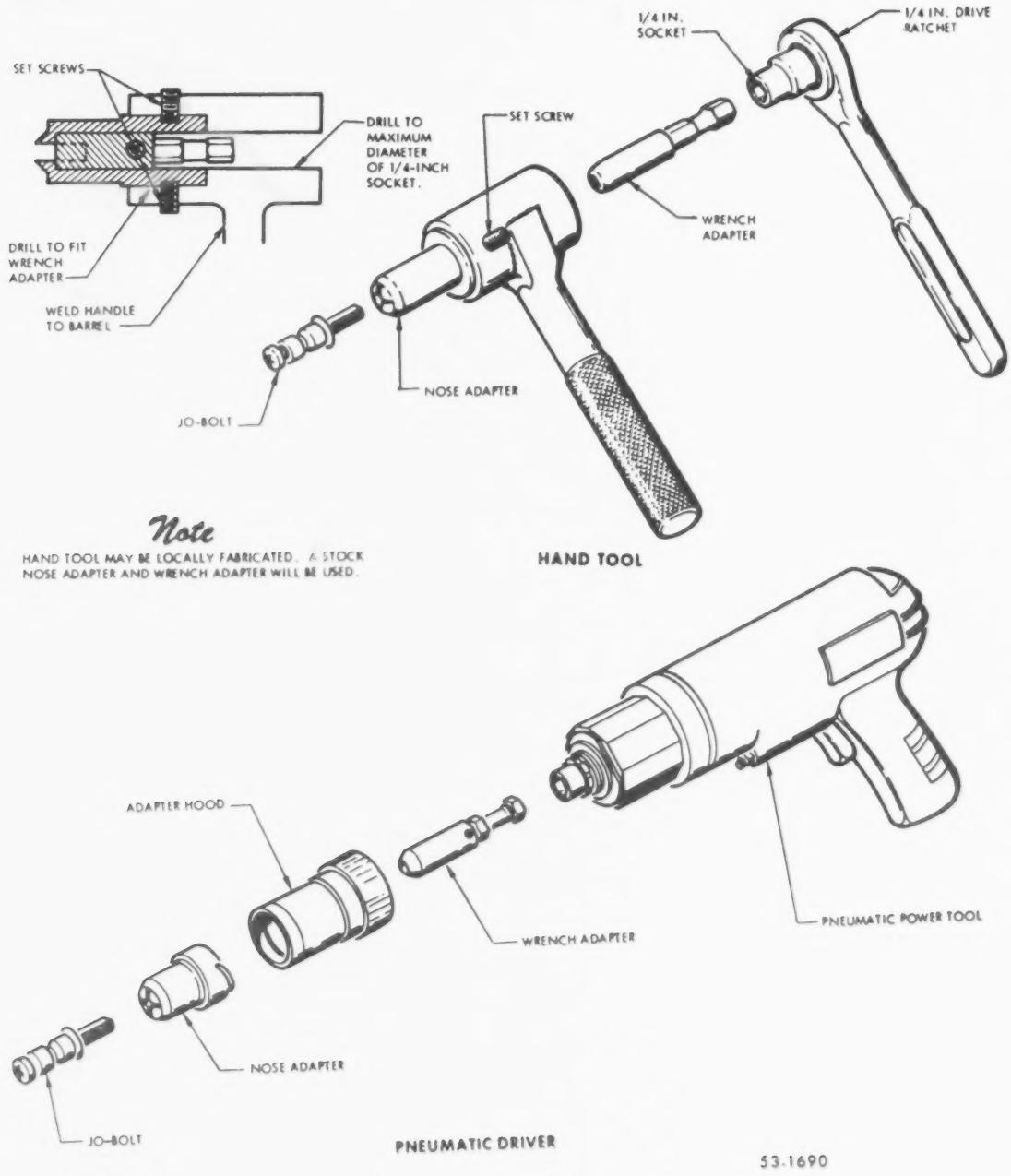


Figure 2-27. Jo-Bolt installation tools.

lengths, the shorter of the two fasteners shall be used. If the proper length Jo-Bolt is not available, one AN960 or NAS1252 series washer may be used under the head of a protruding Jo-Bolt to correct the grip length, in accordance with the following:

- AN960D or NAS1252 aluminum alloy washer shall be used when the faying surfaces are aluminum.
- AN960D or NAS1252 corrosion-resistant steel washer shall be used when the faying surface of joint members are corrosion resistant steel.
- AN960 cadmium plated carbon steel washer shall be used when faying surfaces of joint members are carbon or alloy steel.

b. Preparing installation holes. Close fit holes are required for proper Jo-Bolt installation. Holes shall be straight and perpendicular to the surface against which the manufactured head will bear. Holes shall be round and all burrs must be removed. For best results

666

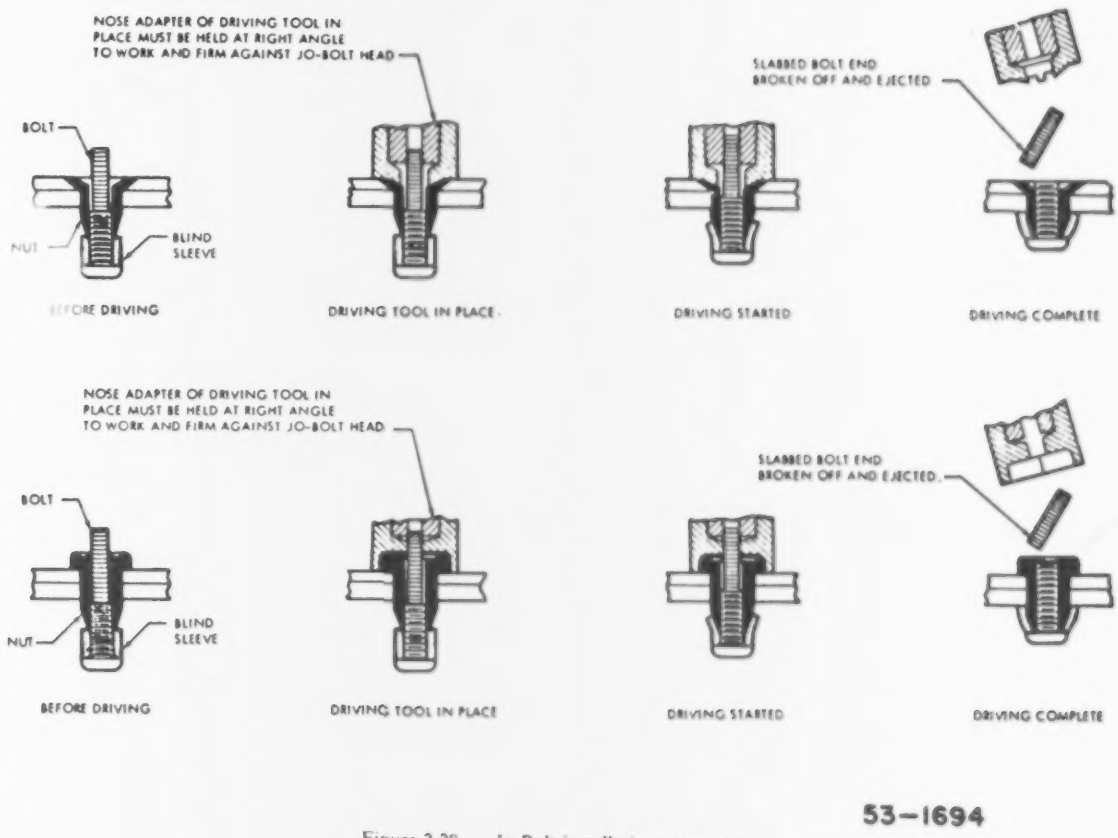

NOSE ADAPTER OF DRIVING TOOL IN PLACE MUST BE HELD AT RIGHT ANGLE TO WORK AND FIRM AGAINST JO-BOLT HEAD
BOLT
NUT
BLIND SLEEVE
BEFORE DRIVING
DRIVING TOOL IN PLACE
SLABBED BOLT END BROKEN OFF AND EJECTED
DRIVING STARTED
DRIVING COMPLETE
NOSE ADAPTER OF DRIVING TOOL IN PLACE MUST BE HELD AT RIGHT ANGLE TO WORK AND FIRM AGAINST JO-BOLT HEAD
BOLT
NUT
BLIND SLEEVE
BEFORE DRIVING
DRIVING TOOL IN PLACE
SLABBED BOLT END BROKEN OFF AND EJECTED
DRIVING STARTED
DRIVING COMPLETE
53-1694

Figure 2-28. Jo-Bolt installation sequence.

holes for Jo-Bolts should be drilled under size and then brought up to final size for reaming. Hole sizes for Jo-Bolts are as follows:

Jo-Bolt Diameter	*Pre-Drill Size*	*Final Hole Size*
5/32	#25	0.1650—0.1680
3/16	#15	0.1990—0.2020
1/4	D	0.2600—0.2630
5/16	L	0.3125—0.3155
3/8	S	0.3750—0.3780

Jo-Bolts should be easily pushed into a properly prepared hole. In no case shall a Jo-Bolt be driven forcibly in the hole. A very light tap fit is permissible in aluminum alloy but not in steel parts.

c. Installation procedures. Once the holes are prepared, you are ready to install the Jo-Bolts. You can install Jo-Bolts either by hand or with penumatically operated installation tools, as shown in figure 2-27. The most important thing to remember when using these tools is that the nose and wrench adapter must be properly matched to the Jo-Bolt being installed. The nose adapter must match the head style and diameter of the Jo-Bolt, and the wrench adapter must match the diameter of the bolt stem.

The following procedures should be followed during the driving of a Jo-Bolt:

- Insert the Jo-Bolt into the hole.
- Place the nose adapter of the driving tool over the bolt stem and press the nose adapter downward making sure it engages the head of the Jo-Bolt.
- Hold the driving tool firmly against the Jo-Bolt and perpendicular to the surface of the work. Failure to do so may cause the bolt stem to break off before the Jo-Bolt is tight.
- Apply power. As power is applied, turn the bolt while holding the nut. The sleeve, compressed between the bolt head and the control end of the nut, expands over the taper, forming the blind head against the surface of the inner member. As driving is completed, the bolt stem snaps off. (Refer to fig. 2-28).
- Touch up the end of the bolt at the breakoff point, after driving is completed, with zinc chromate primer.
- Inspect the completed installation for compliance with applicable technical order limits.

When installing millable head Jo-Bolts, you must inspect them before shaving them. You may use a standard rivet shaver equipped with a carbide cutter to shave the millable head Jo-Bolt flush with the material surface. For best results, use a shaver that turns at least 10,000 RPM. Jo-Bolts that require sealant must be disassembled and each part coated with sealant, then reassembled.

Exercises (622):

1. What factor determines the length of a Jo-Bolt required for installation?

2. Describe the methods used to measure the length of the different head styles of Jo-Bolts.

3. When a grip length measurement indicates a borderline case between two grip lengths, what should you do?

4. For best results, how should Jo-Bolts holes be prepared?

623. Supply detail information concerning the inspection of installed Jo-Bolt fasteners.

Flushness requirements. Installation of flush-head Jo-Bolts on aerodynamic surfaces shall conform to the flush requirements of the area where they are installed. Flush-head Jo-Bolts installed on nonaerodynamic surfaces shall be within 0.015 of an inch above to 0.006 of an inch below the surface. Shaving of steel Jo-Bolt heads to meet the flush requirements is not permitted. Gaps between the manufactured heads of both flush and protruding Jo-Bolts and the surface are permitted if they meet TO specifications. Gaps between faying surfaces shall not exceed 5 percent of the thickness of the thinnest member when measured at the shank of the Jo-Bolt. No more than two adjacent fasteners shall have the maximum permissible gap, and in no case shall the maximum gap exceed 0.015 of an inch. When gapping occurs, you should take steps to eliminate its cause. In areas where the Jo-Bolt blind heads can be seen after installation, they should be visually inspected. Figure 2-29, depicts the various conditions to look for when a blind side head is visible.

Tightness requirements. Check each newly installed Jo-Bolt for looseness. Use a nose adapter attached to a torque wrench to check torque requirements as follows:

Jo-Bolt Diameter	*Torque Limits (Inch-Pounds)*
5/32	4
3/16	6
1/4	10
5/16	20
3/8	30

Apply torque in a clockwise direction only. The Jo-Bolt resistance to the torque valves must be met whether tested on wet or cured sealant, except the 5/32 of an inch Jo-Bolts which are required to withstand only 2 inch pounds maximum torque. If the Jo-Bolt turns when a light torque is applied, it must be removed and replaced.

NOTE: At no time should a screwdriver be used to check the torque of Jo-Bolts.

Spacing requirements. You must inspect not only the Jo-Bolt itself, but also the spacing of the Jo-Bolts within a repair. Minimum edge distance for flush or protruding head Jo-Bolts is two times the nominal diameter plus 0.06 of an inch or as specified in a specific repair procedure. Minimum spacing between protruding head Jo-Bolts shall not be less than three and one half times the nominal diameter. Spacing between flush and millable head Jo-Bolts shall not be less than four times the Jo-Bolt diameter.

The maximum sloping surface against which the Jo-Bolt sleeve may be formed is 8°.

Exercises (623):

1. When is it necessary to remove flush head Jo-Bolts which are installed on aerodynamic surfaces?

2. What are the flushness requirements for Jo-Bolts installed on nonaerodynamic surfaces?

3. What factors directly affect the torque limits of Jo-Bolt fasteners?

4. If you were inspecting a complete repair involving the use of Jo-Bolts, what are the minimum spacing requirements for each type that must be maintained?

624. Given instances of defective Jo-Bolts, state the procedures used to remove each.

Jo-Bolt removal. It will be necessary for you to remove Jo-Bolts under two conditions. The first condition will involve removing Jo-Bolts which are tight and do not rotate in the hole. This condition usually involves removing existing Jo-Bolts in a repair area or when too short a Jo-Bolt has been installed. The second condition is when a Jo-Bolt is loose and rotates within the hole. This usually results from installing a Jo-Bolt that is too long. Regardless of the condition

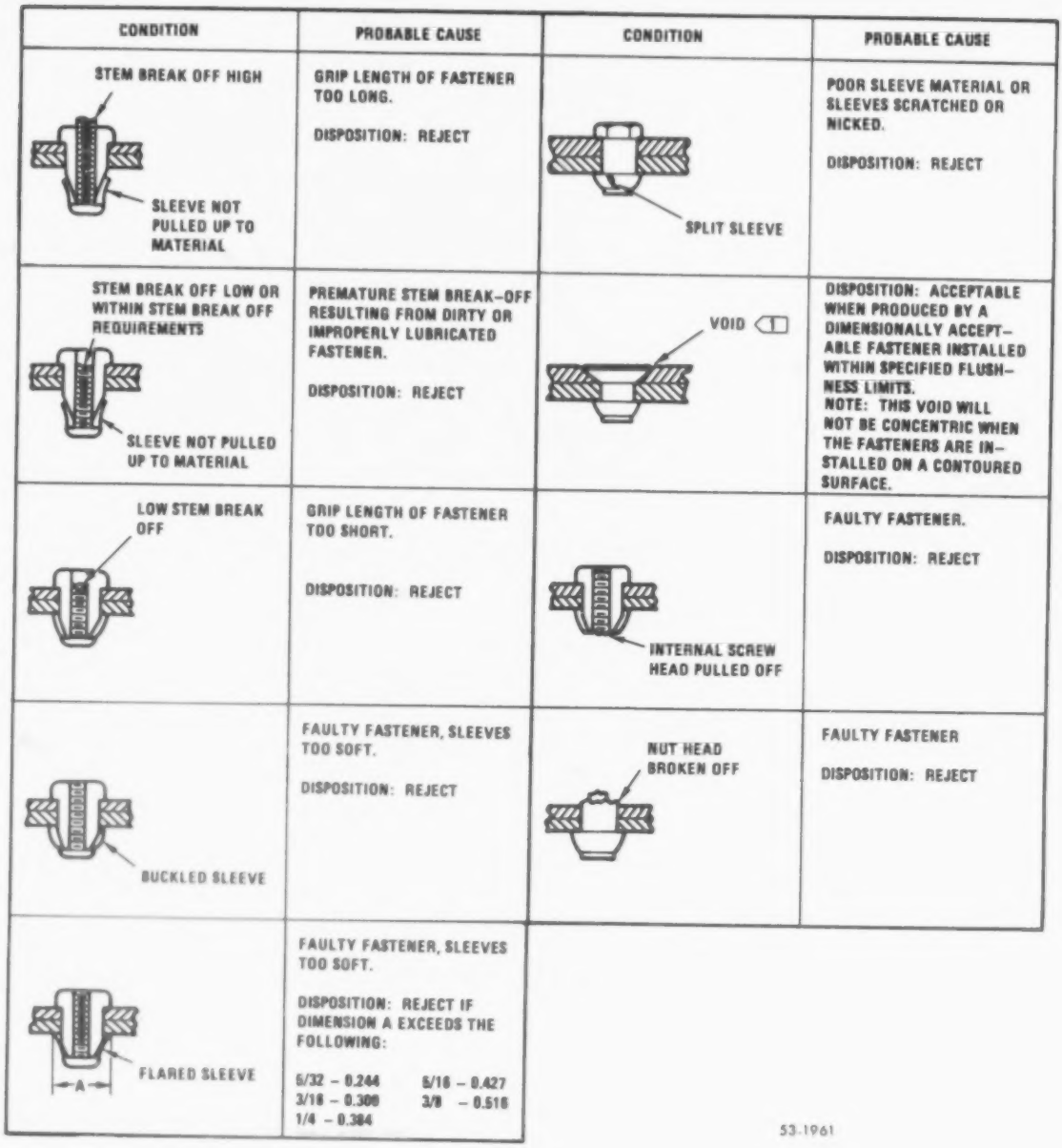

CONDITION
PROBABLE CAUSE
CONDITION
PROBABLE CAUSE
STEM BREAK OFF HIGH
SLEEVE NOT PULLED UP TO MATERIAL
GRIP LENGTH OF FASTENER TOO LONG.
DISPOSITION: REJECT
SPLIT SLEEVE
POOR SLEEVE MATERIAL OR SLEEVES SCRATCHED OR NICKED.
DISPOSITION: REJECT
STEM BREAK OFF LOW OR WITHIN STEM BREAK OFF REQUIREMENTS
SLEEVE NOT PULLED UP TO MATERIAL
PREMATURE STEM BREAK-OFF RESULTING FROM DIRTY OR IMPROPERLY LUBRICATED FASTENER.
DISPOSITION: REJECT
VOID
DISPOSITION: ACCEPTABLE WHEN PRODUCED BY A DIMENSIONALLY ACCEPTABLE FASTENER INSTALLED WITHIN SPECIFIED FLUSHNESS LIMITS.
NOTE: THIS VOID WILL NOT BE CONCENTRIC WHEN THE FASTENERS ARE INSTALLED ON A CONTOURED SURFACE.
LOW STEM BREAK OFF
GRIP LENGTH OF FASTENER TOO SHORT.
DISPOSITION: REJECT
INTERNAL SCREW HEAD PULLED OFF
FAULTY FASTENER.
DISPOSITION: REJECT
BUCKLED SLEEVE
FAULTY FASTENER, SLEEVES TOO SOFT.
DISPOSITION: REJECT
NUT HEAD BROKEN OFF
FAULTY FASTENER
DISPOSITION: REJECT
A
FLARED SLEEVE
FAULTY FASTENER, SLEEVES TOO SOFT.
DISPOSITION: REJECT IF DIMENSION A EXCEEDS THE FOLLOWING:
5/32 – 0.244
3/16 – 0.308
1/4 – 0.384
5/16 – 0.427
3/8 – 0.516
53-1961

Figure 2-29. Jo-Bolt inspection standards.

requiring Jo-Bolt removal, you should select a power drill motor that does not turn over 500 rpm.

a. Removal procedure — nonrotating Jo-Bolts. To remove Jo-Bolts that are tight and do not rotate, select a pilot drill based on the size of Jo-Bolt to be removed, and drill a pilot hole to the head and shank juncture of the Jo-Bolt. Step 1 of the removal procedures shown in the top half of figure 2-30, illustrated this drilling procedure. After completing the pilot drilling, select a larger twist drill, slightly smaller than the diameter of the Jo-Bolt, and drill to same depth as the pilot drill hole. (See Step 2, upper section of fig. 2-30.) When the required drill is completed, take a punch and hammer, sever the Jo-Bolt head, and drive out the shank and blind head. (See Step 3, upper section of fig. 2-30.)

b. Removal procedures — rotating Jo-Bolt. To remove Jo-Bolts that are loose and that rotate, select a twist drill based on the diameter of the Jo-Bolt being removed. Prevent the Jo-Bolt from turning by using a drill bushing fixture having either "dogs" to engage the head slots for flush Jo-Bolts or a wrench recess for hexagon head Jo-Bolts. Drill completely through the shank of the Jo-Bolt, severing the bolt head. Remove

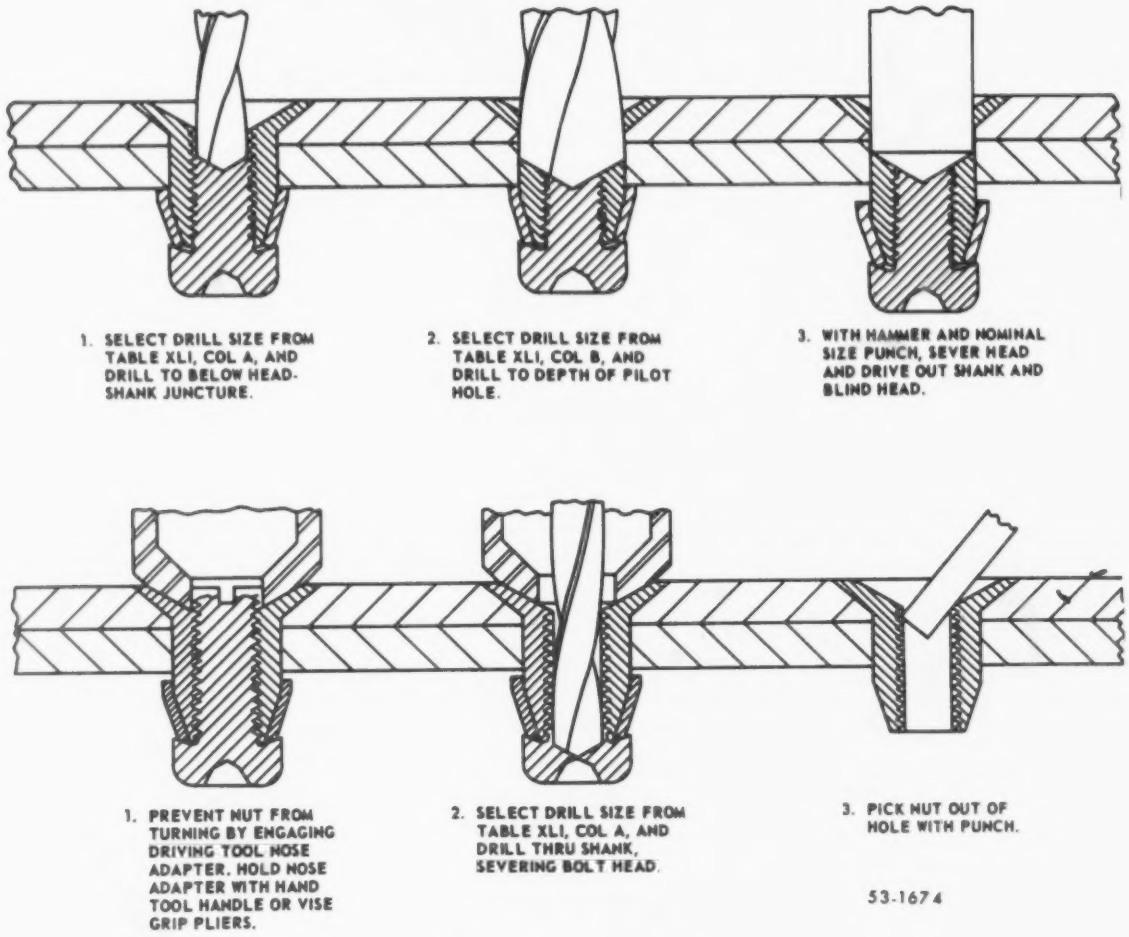

1. SELECT DRILL SIZE FROM TABLE XLI, COL A, AND DRILL TO BELOW HEAD-SHANK JUNCTURE.
2. SELECT DRILL SIZE FROM TABLE XLI, COL B, AND DRILL TO DEPTH OF PILOT HOLE.
3. WITH HAMMER AND NOMINAL SIZE PUNCH, SEVER HEAD AND DRIVE OUT SHANK AND BLIND HEAD.
1. PREVENT NUT FROM TURNING BY ENGAGING DRIVING TOOL NOSE ADAPTER. HOLD NOSE ADAPTER WITH HAND TOOL HANDLE OR VISE GRIP PLIERS.
2. SELECT DRILL SIZE FROM TABLE XLI, COL A, AND DRILL THRU SHANK, SEVERING BOLT HEAD.
3. PICK NUT OUT OF HOLE WITH PUNCH.
53-1674

Figure 2-30. Jo-Bolt removal procedures.

the remaining nut from the hole with a punch. The center portion of figure 2-30, illustrates this removal procedure.

c. Special removal tool. Figure 2-31, illustrates a removal tool especially designed for removing Jo-Bolts. Take a few minutes and study the parts that make up the removal tool. The "heart" of this removal tool is the carbide bur, which looks very similar to a rotary file. Each diameter Jo-Bolt requires a different size carbide bur, along with a nose adapter which matches the diameter and head style of the Jo-Bolt being removed. Step-by-step procedures for removing Jo-Bolts with this tool are outlined in figure 2-32. Take a few minutes and run through the steps before proceeding to the review exercises.

Exercises (624):

1. List the steps to follow when removing a defective Jo-Bolt that is tight and does not rotate within the hole.

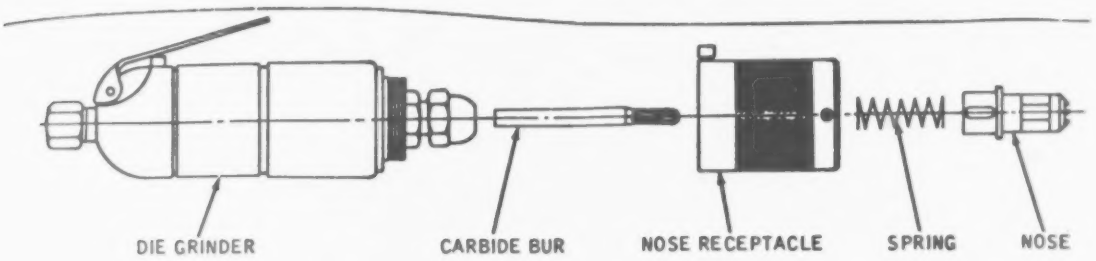


Figure 2-31. Jo-Bolt removal tool.

FASTENER REMOVAL INSTRUCTIONS

STEP 1 SELECT APPROPRIATE CARBIDE BUR AND NOSE TO FIT, SIZE AND HEAD STYLE OF FASTENER TO BE REMOVED.

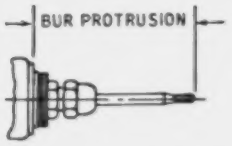
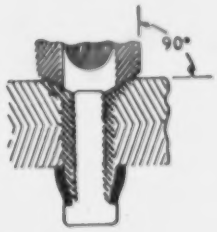


TABLE 9 – INITIAL BUR PROTRUSION

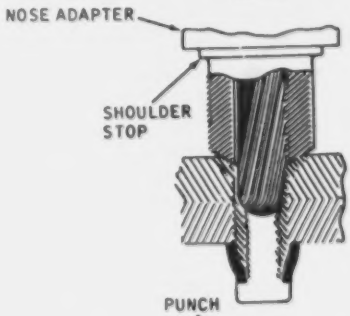
FASTENER NOM DIAMETER	BUR PROTRUSION (REF)	
	FLUSH HEAD FASTENERS	PROTRUDING HEAD FASTENERS
5/32	2.950	2.965
3/16	2.965	2.981
1/4	3.017	3.012
5/16	3.065	3.043
3/8	3.109	3.075

STEP 2 INSTALL BUR INTO DIE GRINDER WITH INITIAL BUR PROTRUSION SHOWN IN TABLE 9. BUR POSITION MAY HAVE TO BE EXTENDED LATER IF DIFFICULTY IS ENCOUNTERED IN PUNCHING OUT THE FASTENER. SEE STEP 5 BELOW.

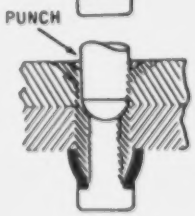
STEP 3 ENGAGE NOSE OF REMOVAL TOOL WITH WRENCHING ELEMENT OF FASTENER, HOLDING TOOL APPROXIMATELY PERPENDICULAR TO TOP OF FASTENER.



STEP 4 START TOOL AND THEN APPLY FORWARD PRESSURE AGAINST FASTENER. CONTINUE FORWARD MOTION UNTIL SHOULDER OF NOSE STOPS AGAINST NOSE ADAPTER.



STEP 5 WITH A HAMMER AND PUNCH, SEVER REMAINING PORTION OF NUT HEAD AND DRIVE OUT SHANK AND BLIND HEAD.



83–1714

Figure 2-32. Jo-Bolt removal tool—removal sequence.

671

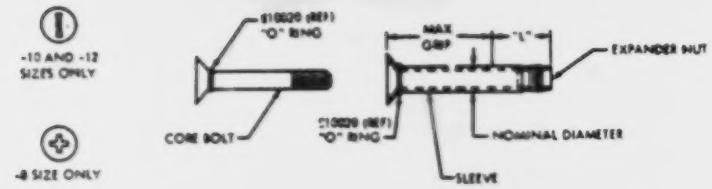


Figure 2-33. Hi-Shear threaded blind bolt. (Sealant type.)

2. State the procedures for removing a Jo-Bolt which is loose and rotates within the hole.

625. State characteristic features of Hi-Shear threaded blind bolts.

Hi-Shear Threaded Blind Bolts. Hi-Shear threaded blind bolts are three-piece assemblies each consisting of a ductile sleeve, a self-locking nut-like expander, and a heat-treated, high strength core bolt. A special Hi-Shear threaded blind bolt which consist of the same three parts plus two rubber O-rings is available for sealing purposes. Figure 2-33 shows this type of threaded blind bolt. Hi-Shear threaded blind bolts are used where loads are primarily shear. The minimum shear strength is 125,000 psi.

Hi-Shear threaded blind bolts are designed to be installed—from one side of the work, where there is no access to the opposite side. They are as strong as NAS bolts; can be used in temperatures up to 1200° F. (except sealant type); and have excellent resistance to vibration and fatigue strength. They are available in protruding or countersunk head styles with either Hi-torque or Phillips recess heads. The sealing type Hi-Shear thread blind bolt is made in the countersunk head style only. Each fastener consist of a cadmium-plated type 431 stainless core bolt. The type of wrenching recess found on the head of the core bolt will depend on the diameter of blind bolt. Smaller sizes will have the Phillip's types of recesses, whereas larger sizes will have the Hi-torque types of recesses.

Identification system. The countersunk Hi-Shear threaded blind bolt is identified by the basic assembly number BB351, the protruding head-type by BB352, and the sealant type by the part number BB362. These numbers include the complete assemble of core bolt, sleeve, and expander. Separate part numbers are available for each individual part. A breakdown of the part number BB 351-8-12 is as follows:

BB351 (Basic Assembly Number)	100° countersunk Hi-Shear blind bolt assembly which includes: BB301 core bolt, BB321 PB sleeve, and BB341PB expander.
-8	Indicates the diameter measured in 1/32 increments (1/4 of an inch).
-12	Indicates the grip length measured in 1/16 increments (3/4 of an inch).

The letter "G" after the basic assembly number indicates a silver plated expander. The letters "P" or "PB" after the basic assembly number indicate the type of cadmium plate.

Exercises (625):

1. Name the parts that make up a Hi-Shear threaded blind bolt.

2. What are the head styles of Hi-Shear threaded blind bolts?

3. What fractional measurements are used to indicate the diameter and grip length of Hi-Shear threaded blind bolts?

626. Give significant details relating to the installation of Hi-Shear threaded blind bolts.

Preinstallation procedures. As with all fasteners, the final results of the installation can be directly traced to hole preparation, selection of the proper grip length, and the use of installation tool.

a. Hole preparation. Holes drilled for Hi-Shear threaded blind bolts should produce a close fit to insure that the maximum strength is obtained when the bolt assemble is installed. Holes should be pilot-drilled and then reamed to the final size. Final hole sizes for the different diameters are as follows:

Diameters	*Fianl Hole Size*
-5	.171
-6	.198
-8	.259
-10	.340
-12	.392

Hole must be perpendicular to the work surface and free of all burrs. When you install countersunk Hi-Shear threaded blind bolts, the countersink should

produce a flush fastener installation which conforms to the aircraft's contour smoothness requirements.

b. Determining required grip length. Hi-Shear threaded blind bolts are coded to the average grip length with a plus or minus 1/32 of an inch allowance. This permits a 1/16 of an inch variation in material thicknesses that can be jointed with one size blind bolt. Also, this eliminates changing to the next longer or shorter grip length in borderline cases. Grip range charts are usually given in the specific -3 TO. When taking measurement for grip length, insure that the metal is tightly clamped together.

c. Installation tools. Hi-Shear threaded blind bolt are installed with either hand or power operated tools. For purposes of our discussion, the hand operated tools will be covered. The upper left hand illustration on figure 2-34 shows the initial set up involving the use of hand-operated installation tools. Also required will be a standard torque wrench with a crow foot wrench attached, and a socket or open end wrench. The diameter of the blind bolt being installed and the grip length requirements will influence your tool selection. You should always consult the specific -3 TO for proper tool selection.

Installation procedures. Once you have completed all preinstallation procedures, you are ready to install the blind bolts. The following sequence lists the installation procedures: (Refer to fig. 2-34, as the steps are covered.)

1. Slip the sleeve of the blind bolt on to the mandrel, and spin the expander onto the threaded end of the mandrel until it is finger tight.
2. Turn the chuck bolt clockwise to seat the anvil firmly against the head of the sleeve. This action prevents the sleeve from turning during installation.
3. Install the crow foot wrench and socket wrench onto the tool body assemble.
4. Insert the expander and sleeve fully into the hole in the work surface.
5. Using socket or open end wrench to hold the chuck bolt, turn the tool body in a counterclockwise direction with the crow foot wrench.
6. Continue turning the crow foot wrench until the expander resists the wrenching action. To prevent mandrel breakage from overtorqueing (particularly on the -5, -6, and -8 sizes) do not exceed torque loads listed in TO specifications.
7. Remove the tool by turning the tool body clockwise a half turn.
8. Unscrew the chuck bolt from the expander threads. NOTE: When a sealant type Hi-Shear threaded blind bolt is being installed (like the one shown in fig. 2-33), O-rings are installed prior to the insertion of the blind bolt into the work surface.

To complete the installation, install a core bolt. The core bolt length is critical and must be the proper length to prevent the sleeve from turning in the hole. The lower illustration in figure 2-34 depicts the different methods used to determine the correct core bolt length required. Special grip length gages are available from the manufacturers of Hi-Shear threaded blind bolts. NOTE: Hi-Shear threaded blind bolts must not be cleaned in any manner that results in the removal of the lubricant applied by the manufacturer. No lubricant, other than that applied by the manufacturer, shall be applied to a threaded blind bolt.

Exercises (626):

1. How should holes be prepared for Hi-Shear threaded blind bolts?

2. List the hand tools that are needed to install Hi-Shear threaded blind bolts.

3. Describe the function of each of the hand tools, you listed in exercise 2.

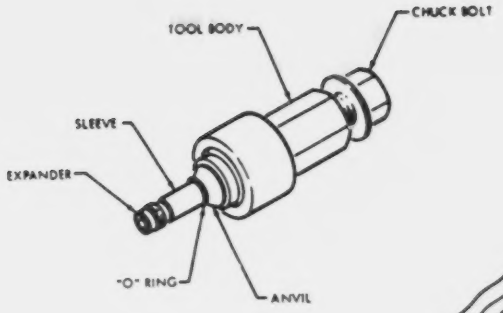
627. Given descriptions of installed Hi-Shear threaded blind bolts, determine if they should be replaced; list in the steps in the removal procedure.

Inspection criteria. Inspection of installed Hi-Shear threaded blind bolts is limited to the manufactured head. The sleeve must be tight in the hole and must not turn when the core bolt is installed. Flush head blind bolt assemblies on aerodynamic surfaces must conform to the area of installation contour smoothness requirements. Flush head blind bolts installed on an nonaerodynamic surface shall be within 0.015 inch above to 0.006 inch below the surface. Shaving of steel fastener heads to meet flushness requirements is not permitted. Gaps between the head of blind bolts and the work surface range from 0.0025 to 0.004 depending on the diameter of the blind bolt. Also, at least 50 percent of a flush head blind bolt head must be bearing against the countersunk or dimpled holes. For protruding head-type, at least some portion of the head must be bearing against the surface, before gaps are allowed.

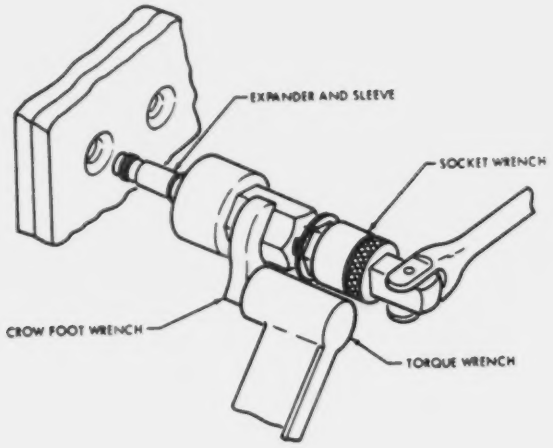
Gaps between faying surface of fastened members shall not exceed 5 percent of the thickness of the thinnest member when measured at the shank of the fasteners. No more than two adjacent fasteners shall have the maximum permissible gap and in no case shall the maximum gap exceed 0.015 of an inch.

Removal procedures. When it is necessary to remove a Hi-Shear threaded blind bolt, you should make every effort not to damage the hole and surrounding surfaces. Removal procedures are as follows:

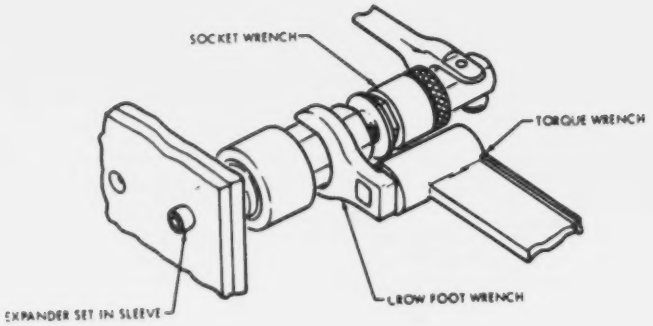
1. Remove the core bolt from the sleeve.
2. Drill through the head of the sleeve with a twist



STEP 1. SLIP THE SLEEVE OF THE FASTENER ONTO THE MANDRIL AND SPIN THE EXPANDER ONTO THE THREADED END OF THE MANDREL UNTIL IT IS FINGER TIGHT. TURN THE CHUCK BOLT CLOCKWISE TO SEAT THE ANVIL FIRMLY AGAINST THE HEAD OF THE SLEEVE.

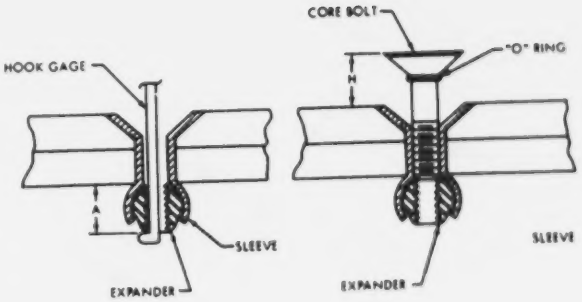


STEP 2. INSERT THE EXPANDER AND SLEEVE FULLY INTO THE HOLE IN THE WORK.



STEP 3. USE A WRENCH TO HOLD THE CHUCK BOLT AND TURN THE TOOL BODY IN A COUNTER-CLOCKWISE DIRECTION WITH A TORQUE WRENCH WITH CROW FOOT WRENCH UNTIL THE EXPANDER RESISTS THE WRENCHING ACTION. REMOVE THE TOOL BY TURNING THE BODY CLOCKWISE A HALF TURN TO LOOSEN AND UNSCREW THE CHUCK BOLT FROM THE EXPANDER THREADS

FASTENER	DIMENSION "A" MAXIMUM	DIMENSION H MINIMUM	DIMENSION H MAXIMUM
88362-8	.28	.31	.39
88362-10	.39	.37	.49
88362-12	.45	.43	.56



53-1700

Figure 2-34. Hi-Shear thread blind bolt installation data.

drill 1/32 of an inch smaller in diameter than the sleeve diameter.

3. Remove head of sleeve.

4. Drive out the sleeve and expander with drift punch and hammer.

If the hole was not damaged during removal, a replacement of the same size diameter blind bolt may be reinstalled. Oversized Hi-Shear threaded blind bolts should be used only when approved by an aeronautical structure engineer.

Exercises (627):

1. After reading the description of an installed Hi-Shear threaded blind bolt in column 1, indicate in column 2, by the word "Yes or No", whether the blind bolt needs to be removed.

	Column 1	*Column 2*
a.	A flush-type blind bolt has a gap of 0.005 of an inch between the head and work surface, 75 percent of the head is bearing against the surface.	*a.* _____
b.	A protruding head-type blind bolt has a gap of 0.0025 of an inch between the head and the work surface. The head is not contacting the surface.	*b.* _____
c.	A flush head blind bolt installed on the interior of an aircraft is 0.010 of an inch above surface.	*c.* _____

2. List the steps followed in removing Hi-Shear threaded blind bolts.

628. State the principal features of mechanical-lock blind bolts.

Mechanical-Lock Blind Bolts. Mechanical-lock blind bolts incorporate the positive locking features of a mechanical-lock blind rivet and the high strength requirements of NAS conventional bolts. Each mechanical-lock blind bolt consists of a shank and a pulling pin. The shank incorporates a long cylindrical sleeve, a locking collar, and a conical recess to accommodate the locking collar when the bolt is driven. The pin consists of a grooved pulling section, which protrudes above the rivet head and fits into the jaws of the pulling gun; and a locking groove portion, which receives the locking collar. The pin's blind end section incorporates a head and a land section with an extruding angle which expands the bolt shank to form the blind head when driven.

The positive mechanical-lock design features of mechanical-lock blind bolts does away with the uncertainty of the threaded blind bolts. The shear and tensile strengths of mechanical-lock blind bolts exceeds NAS requirements. Also, they have exhibited excellent reliability in areas subject to high vibrations.

Mechanical-lock blind bolts are available in 100° flush head style and the protruding head style as shown in figure 2-35. Both types are fabricated from either alloy steel or stainless steel. Diameter sizes range from 5/32 of an inch through ½ inch. Grip lengths are available up to 2½ inches in length.

Coding system. Mechanical-lock blind bolts can be identified by either the MS number or the manufacturer's part number. The lower portion of figure 2-33, illustrates the breakdown of an MS number. A breakdown of a typical manufacturer's part number is as follows:

Example	B100-T8-3
B100-T	Huck fastener identification for a 100° countersunk head, alloy steel, high strength pull type, positive mechanical-lock blind bolt. (T - represents alloy steel)
8	Diameter - indicated in 32nds of an inch.
-3	Grip length - indicated in 16th of an inch.

NOTE: A dash number stamped on the head of the blind bolt indicates the grip length.

Exercises (628):

1. List the component of the shank portion of a mechanical-lock blind bolt.

2. State the function of each portion of the pin used in a mechanical-lock blind bolt.

3. From the following listing of material composition, circle the letter/s that indicates the materials used to fabricate mechanical-lock blind bolts.
   a. aluminum alloys
   b. titanium alloys
   c. stainless steel
   d. magnesium alloys
   e. alloy steel

629. Explain specific procedures used during the installation of mechanical-lock blind bolts.

Preinstallation factors. Your preinstallation procedures will be determined by whether you are replacing existing blind bolts or installing new blind bolts. When you are replacing existing blind bolts, your first step should be to measure accurately the existing hole to see that it is still within the hole limits for the size diameter you are replacing. If the hole is not within tolerance or is out of round, the hole should be enlarged to tolerances for an oversized blind bolt, which are 1/64 of an inch larger. You must consult the specific -3 TO prior to this action to insure that

MS21140

MS21141

MS90353

MS90354

BASIC PART NUMBER	SHANK DIAMETER		HEAD DIAMETER		
			MS21140 and MS90353	MS21141 and MS90354	
	MIN	MAX	MAX	MIN	MAX
MS90353-4805 and MS90354-4805 MS21140-405 and MS90353-405 MS21141-405 and MS90354-405	.162	.164	.333	.250	.272
MS90353-4806 and MS90354-4806 MS21140-406 and MS90353-406 MS21141-406 and MS90354-406	.197	.199	.386	.305	.332
MS21140-408 and MS90353-408 MS21141-408 and MS90354-408	.258	.260	.507	.400	.432
MS21140-410 and MS90353-410 MS21141-410 and MS90354-410	.310	.312	.634	.480	.522
MS21140-412 and MS90353-412 MS21141-412 and MS90354-412	.372	.374	.762	.580	.627
MS90353-414 and MS90354-414	.435	.437	.890	.675	.727
MS90353-416 and MS90354-416	.496	.499	1.017	.770	.832

Part Number Example

MS90353-10B03

- Nominal grip in 1/16th inch
- Diameter in 1/32nd inch
- Fastener, blind, high strength, pull type, positive mechanical lock, 100 degree flush head, alloy steel, 112 KSI

Alloy steel sizes "03" and "06" insert "S" in place of (-) to designate fastener installed with single action tool. Sizes "03" and "06" with (-) in part number are installed with a double action tool. All other alloy steel sizes with (-) in the part number are installed with a single action tool.

Material

Alloy steel, MIL-F-81177
A-286 Corrosion resistance steel MIL-F-8973

53-1682

Figure 2-35. Mechanical-lock blind bolts.

this is permissible. In cases, where the hole is so far out of tolerance that the next size diameter must be used, approval of a structual engineer is usually required.

When drilling new holes, make every effort to produce a tight fit. Holes should be reamed to final size. Required hole clearances are given in the chart shown on figure 2-35. Holes must be perpendicular to work surface and free of all burrs. When flush-type mechanical-lock blind bolts are being installed, the flushness requirements for the area must be maintained.

After the hole has been prepared, you must select the proper grip length. For replacement of an existing blind bolt, this problem is eliminated because the grip length of the existing fastener is stamped on the

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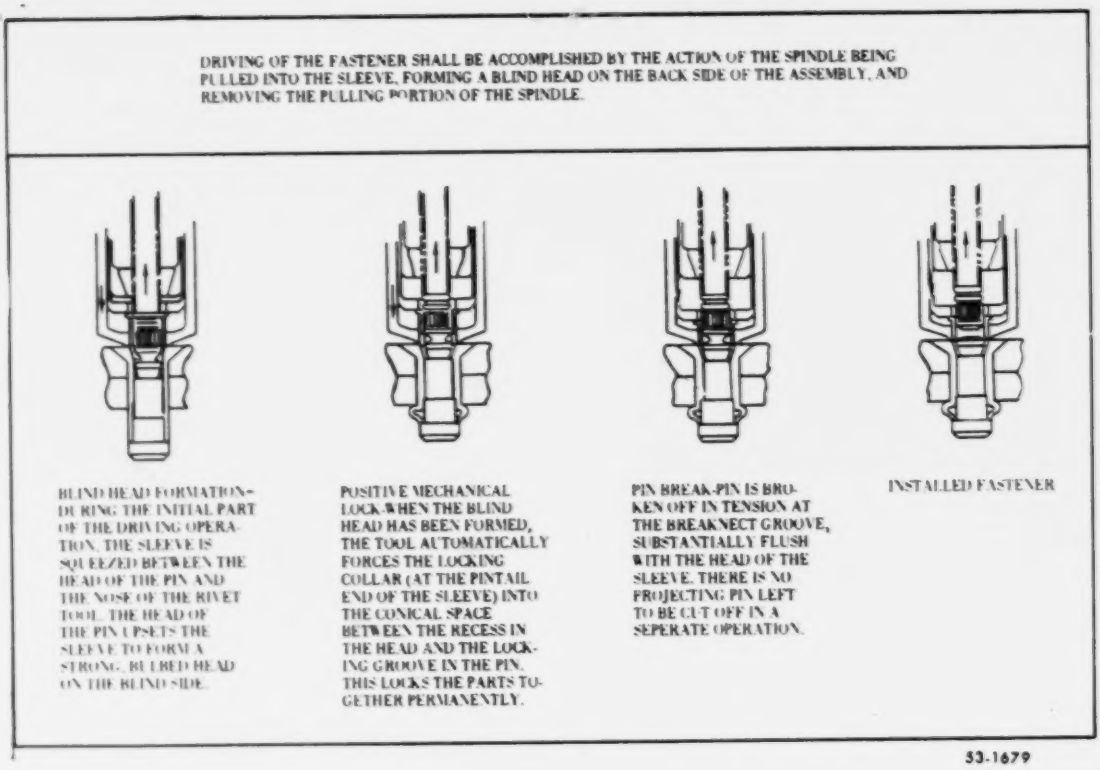

DRIVING OF THE FASTENER SHALL BE ACCOMPLISHED BY THE ACTION OF THE SPINDLE BEING PULLED INTO THE SLEEVE, FORMING A BLIND HEAD ON THE BACK SIDE OF THE ASSEMBLY, AND REMOVING THE PULLING PORTION OF THE SPINDLE.
BLIND HEAD FORMATION-DURING THE INITIAL PART OF THE DRIVING OPERATION, THE SLEEVE IS SQUEEZED BETWEEN THE HEAD OF THE PIN AND THE NOSE OF THE RIVET TOOL. THE HEAD OF THE PIN UPSETS THE SLEEVE TO FORM A STRONG, BULBED HEAD ON THE BLIND SIDE.
POSITIVE MECHANICAL LOCK-WHEN THE BLIND HEAD HAS BEEN FORMED, THE TOOL AUTOMATICALLY FORCES THE LOCKING COLLAR (AT THE PINTAIL END OF THE SLEEVE) INTO THE CONICAL SPACE BETWEEN THE RECESS IN THE HEAD AND THE LOCKING GROOVE IN THE PIN. THIS LOCKS THE PARTS TOGETHER PERMANENTLY.
PIN BREAK-PIN IS BROKEN OFF IN TENSION AT THE BREAKNECT GROOVE, SUBSTANTIALLY FLUSH WITH THE HEAD OF THE SLEEVE. THERE IS NO PROJECTING PIN LEFT TO BE CUT OFF IN A SEPERATE OPERATION.
INSTALLED FASTENER
53-1679

Figure 2-36. Mechanical-lock blind bolt installation data.

manufactured head. In this case, use the same length that the manufacturer used. For new holes, you must follow a different method. You must learn the thickness of the joint before you can select the proper length. To determine the thickness, use the special depth gages which are available from the manufacturer of the blind bolt. Hook-type gages are not recommended because of their inability to remove gaps and because of the human error possible by different sized thumbs. Once you have determined the total thickness, select the correct grip length required.

Installation tools. The diameter and the head style of the mechanical-lock blind bolt being installed will determine the tools you will select. For 5/32 and 3/16 of an inch diameter blind bolts, you must use a pulling gun with a double action. The model 200 Huck installation gun is such a gun. This pulling gun must have the shift pressure valve set for each different diameter blind bolt being installed. Special adjustment kits are available from the manufacturer.

For larger diameter blind bolts, ¼ to ½ of an inch, a single action pulling gun is required. Huck installation guns, models 287 and 353 can be used. These pulling guns must also be adjusted for the specific diameter blind bolt being installed.

The nose adapter must match the head style and diameter of the blind bolt. Each nose adapter includes a set of jaws which grip the grooves on the pin; an outer anvil which bears against the outer part of the manufactured head during the driving operation; and an inner anvil which advances automatically to drive the locking collar home. mechanically locking the pin in place after the blind side head is formed.

Installation procedures. The actual installation of mechanical-lock blind bolts is similar to those procedures followed when installing mechanical-lock blind rivets. Once you have prepared the hole and selected the correct grip length and installation tools, follow these procedures:

1. Insert the blind bolt into the hole.
2. Position the pulling gun over the blind bolt and insert the grooved portion of the pin into the nose adapter.
3. Maintain a downward pressure against the head of the blind bolt, making sure that the pulling gun is held 90° from the work surface.
4. Depress the trigger of the pulling gun, maintaining the downward pressure and proper alignment.
5. Remove the pulling gun from the blind bolt only after the pin breaks. Premature removal will result in the locking collar not seating properly. Figure 2-36 illustrates the sequence of operations that take place during the driving cycle. Take a few minutes and read through the different operations.
6. Inspect the blind bolt for proper installation.

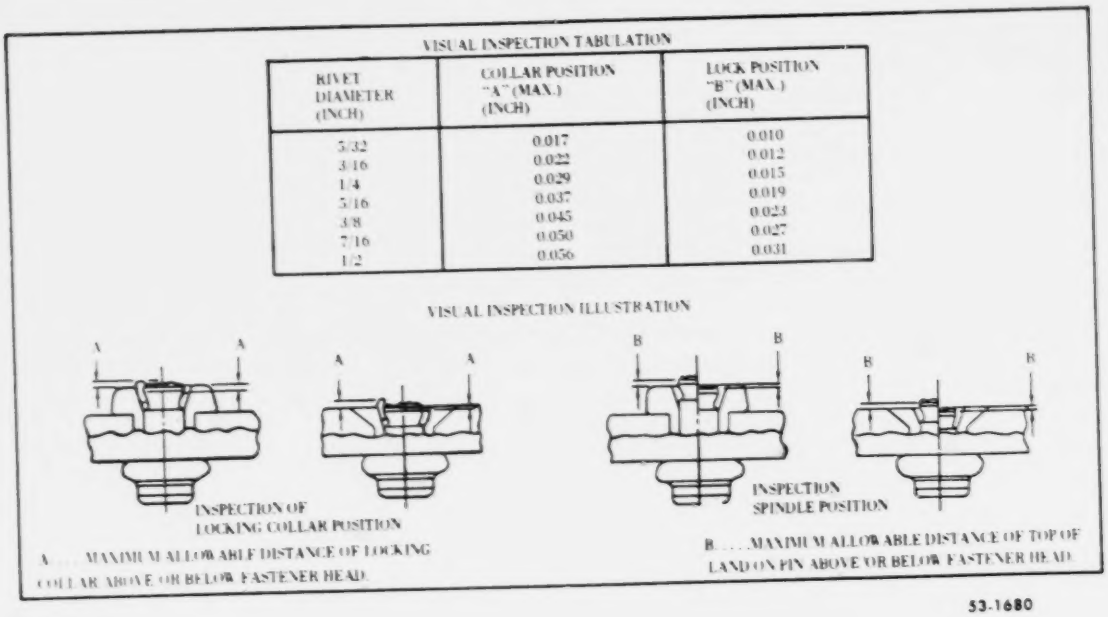


Figure 2-37. Mechanical-lock blind bolt inspection limits.

Exercises (629):

1. Explain what you should do, when replacing mechanical-lock blind bolts if existing fastener holes are oversized.

2. For best results when installing mechanical-lock blind bolts, how should the holes be prepared?

3. After installing flush-head type 3/16 of an inch diameter mechanical-lock blind bolts in a repair, what would you need to do to the installation tools to install ¼ of an inch protruding head-type mechanical-lock blind bolts?

4. What specific action takes place when the mechanical-lock blind bolt is driving?

630. Specify inspection and removal procedures used for mechanical-lock blind bolts.

Inspection procedures. Inspection of installed mechanical-lock blind bolts is limited to three specific areas of the manufactured head: the fit of the manufactured head against the work surface, the position of the pin, and the position of the locking collar.

Flush head mechanical-lock blind bolts installed on aerodynamic surfaces must conform to the aircraft's contour smoothness requirements. Bolt heads should not be shaved or milled to meet flushness requirements. For nonaerodynamic surfaces both the flush and protruding head styles must meet the specific -3 TO requirements.

Gaps between the heads of blind bolts and the work surface caused by burrs or foreign material shall be cause for rejection. Allowable gages under the head of blind bolts will depend on the diameter of the blind bolt and the amount of surface contact. Specific -3 TO will spell out the gap limitations.

Pin and locking collar position refers to the height of both in relation to the head of the shank after installation. Figure 2-37 illustrates methods of measuring the height of the pin and collar. Also a chart listing the allowable limitations is shown. As you can see from the chart, the amount of allowance is based on the diameter of the blind bolt.

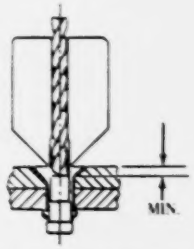
Removal procedures. When it becomes necessary to remove mechanical-lock blind bolts either because of inspection failure or repair procedures, a definite sequence of removal steps must be followed. The removal procedures consist of four operations:

- Operation 1. Drill Pin. A drill motor with a maximum of 1250 rpm is preferred. The drill pin chart shown in the upper right hand corner of figure 2-38 gives the correct sized drill to be used based on the diameter of the blind bolt being removed. A drill bushing fixture should be used to maintain proper alignment during the drilling. The pin is drilled only to the depth stated in the drill pin chart.

DRILL PIN

NOM. SIZE	PART NO.	SIZE	MIN. DEPTH*	BUSHING
5/32"	502999	.0980	.070	10.0615
3/16"	503000	.1250	.070	10.0616
1/4"	503001	.1562	.090	10.0617
5/16"	503003	.1875	.105	10.0618
3/8"	503005	.2500	.130	10.0619

*MAX. DEPTH + .020



PLACE THE DRILL BUSHING OVER THE PIN SO THAT IT RESTS SQUARELY ON THE LOCK COLLAR.

USING A DRILL WITH A MAXIMUM OF 1250 RPM, DRILL TO LOCK COLLAR DEPTH.

KNOCK OUT PIN

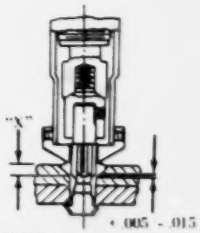
NOM. SIZE	PART NO.	SIZE
5/32"	503010	3/32"
3/16"	503010	3/32"
1/4"	503012	5/32"
5/16"	503013	3/16"
3/8"	503014	7/32"

POSITION PIN PUNCH ON THE FASTENER AND DRIVE FASTENER PIN OUT.

REMOVE REMAINING PORTION OF PIN AND LOCK COLLAR WITH ANY SHARP POINTED INSTRUMENT.

COUNTERBORE SLEEVE

NOM. SIZE	HOLDER	PART NO.	SIZE	ANTI-ROTATION CAP
5/32"	10.0610	10.0605	5/32"	10.0620
3/16"	10.0611	10.0606	3/16"	10.0620
1/4"	10.0611	10.0607	1/4"	10.0621
5/16"	10.0613	10.0608	5/16"	10.0621
3/8"	10.0613	10.0609	3/8"	10.0622



HEAD HEIGHT	
PROTRUDING HEAD	C/SUNK HEAD
5/32" .070	.070
3/16" .135	.090
1/4" .140	.105
5/16" .140	.135
3/8" .205	.165

ADJUST MICRO-LIMIT TOOL TO WITHIN .005 TO .015 LESS THAN DIMENSION "X".

PLACE ANTI-ROTATION CAP FIRMLY AGAINST HEAD OF FASTENER.

COUNTERBORE TO DESIRED DEPTH.

KNOCK OUT SLEEVE

NOM. SIZE	PART NO.	SIZE
5/32"	503012	5/32"
3/16"	503013	3/16"
1/4"	503015	1/4"
5/16"	503016	5/16"
3/8"	503017	3/8"

POSITION THE SLEEVE PUNCH IN THE SLEEVE AND DRIVE OUT LOWER PORTION OF THE SLEEVE.

TIP THE SLEEVE PUNCH SLIGHTLY AND LIFT OUT THE HEAD OF THE FASTENER.

53-1681

Figure 2-38. Mechanical-lock blind bolt removal data.

• Operation 2. Pin Knock Out. After the pin drilling is completed, position a pin punch on the remaining portion of the pin, and drive out the pin. Pin punch sizes are given in the upper left hand chart in figure 2-38.

• Operation 3. Counterboring Sleeve. This operation requires the use of an adjustable micro-limit cutting tool. This tool is used to grind away a portion of the sleeve. The lower left hand illustration in figure 2-38 demonstrates the positioning of this cutter.

• Operation 4. Sleeve Removal. After the sleeve has been counterbored to the desired depth, position a sleeve punch into the remaining portion of the sleeve and drive out the sleeve. Tip the sleeve punch slightly and lift out the head of the sleeve.

NOTE: Blind bolt removal kits are available from manufacturers of mechanical-lock blind bolts.

Exercises (630):

1. Describe the specific areas of the manufacturer head of installed mechanical-lock blind bolts you would check during inspection.

2. List the tools used to remove mechanical-lock blind bolts.

3. Specify the purpose of each of the tools listed in exercise 2.

Turnlock Fasteners

THE FIRST TWO chapters of this volume dealt with permanent type fasteners. Once they were installed, they were removed only when they became loose or when necessary in the course of making a repair. This chapter will take a look at the types of fasteners that are designed to be unfastened and refastened, after being installed.

The first section of this chapter will cover the nonstructural types of turnlock fasteners, such as Dzus, Camloc, and Airloc.

The second section of the chapter will cover the high strength, structural types of turnlock fasteners. The high strength Camloc, the Milson, the Deutsch Zip-Loc and the Colfax fasteners will be discussed. For types not covered, the specific -3 TO will usually give detailed instructions on their use.

3-1. Nonstructural Turnlock Fasteners

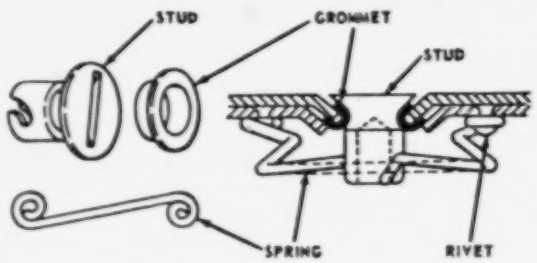
Many locations on the aircraft must be accessible for necessary inspections and maintenance of the various aircraft components. The use of turnlock fasteners makes possible quick and easy removal or installation of cowling, fairings, inspection plates, and access doors. Turnlock fasteners are not strong enough to withstand primary structural stresses and are not used to fasten these structures. The three styles of turnlock fasteners used by the Air Force are style I (Dzus), style II (Camloc), and style III (Airloc). For our discussion, the trade names will be used because of the wide acceptance of these terms in the airframe career field.

631. Differentiate between the types of Dzus turnlock fasteners.

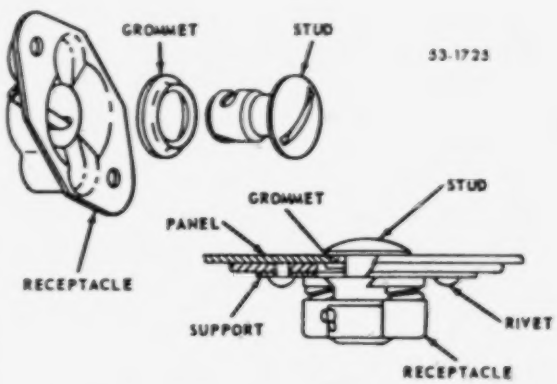
Dzus Fasteners. Two types of Dzus turnlock fasteners are used on today's aircraft—the heavy-duty type and the light-duty type. The heavy-duty type is usually found on the exterior of the aircraft for securing engine cowling, large access panels, and fairings. The light-duty type is primarily found in the cockpit area of an aircraft to secure instrument panels or individual instruments in place.

Heavy-duty Dzus fasteners. The heavy-duty fastener consists of a stud, a grommet, and either a spring or receptacle. Figure 3-1, illustrates installed studs incorporating both the spring and receptacle. The grommet is made of aluminum or aluminum alloy (1100-H14) material. It acts as a holding device which prevents the stud from falling out of the hole when the stud is unlocked. Grommets may be fabricated from 1100 aluminum tubing if none are available from normal sources.

The spring is made of cadmium-plated steel to prevent corrosion. The spring supplies the force that locks or secures the stud in place when two assemblies are joined. The receptacle, on the other hand, has a heat-treated steel base and cadmium plated music wire springs. Receptacles are available in two types, rigid



DZUS FASTENER (STUD, GROMMET, AND SPRING)



DZUS FASTENER (STUD, GROMMET, AND RECEPTACLE)

Figure 3-1. Dzus turnlock fastener parts.

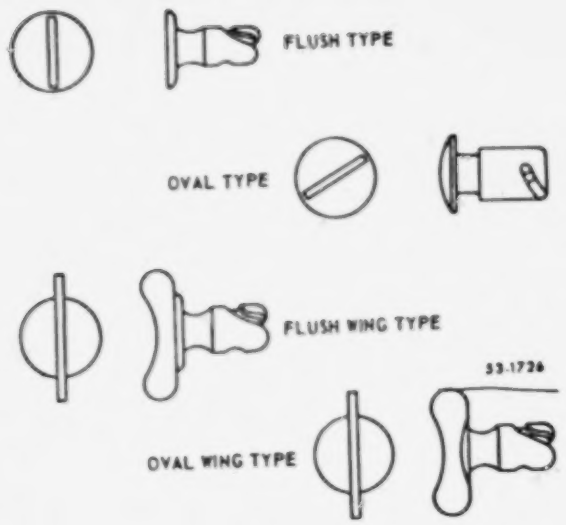


Figure 3-2. Dzus turnlock fastener head styles.

and floating. The receptacle is fully enclosed to protect the fastener parts and has a smooth, beveled entrance to guide the stud into the locking position.

Studs are made of SAE2317 nickel steel, heat-treated and cadmium plated. They are available in three styles: flush, oval, and winged, as shown in figure 3-2. Studs are available in different lengths for different thicknesses of material. Stud length is measured in hundredths of an inch from the head of the stud to the bottom of the spring hole. The diameter is measured in sixteenths of an inch. Body diameter, length, and head type are identified by the markings found on the head of the stud. Figure 3-3 illustrates these markings.

Light-duty Dzus fasteners. Light-duty Dzus fasteners, sometimes referred to as Panel Line Fasteners, consist of a stud, a coiled spring, cup, and receptacle assembly. Figure 3-4 illustrates the individual parts and their part numbers. The stud and spring are fabricated from aluminum alloy. The receptacle assembly consists of a 90° extruded aluminum alloy angle, with a built in locking wire. Predrilled holes are evenly spaced along the top flange of the extruded angle. Replacement receptacle assemblies come from supply in 4 foot sections which enables you to cut off the specific length required.

Exercises (631):
In the space provided in front of each statement, indicate whether the statement is related to a heavy-duty or a light-duty Dzus turnlock fastener by placing the letter H for the heavy-duty or the letter L for light-duty.

_____ 1. Consists of four parts.
_____ 2. 100 aluminum alloy tubing can be used for grommets.
_____ 3. Receptacles are either rigid or floating.
_____ 4. Extruded aluminum alloy angle is used.
_____ 5. Found mostly in the cockpit area of the aircraft.
_____ 6. Available in three head types.
_____ 7. Locking spring held in place by rivets.
_____ 8. Found primarily on the exterior areas of the aircraft.
_____ 9. Receptacle assembly is cut to specific lengths.
_____ 10. Has an aluminum alloy cup.

632. Point out factors relation to the initial installation and removal of heavy-duty Dzus type turnlock fasteners.

Installation procedures for heavy-duty Dzus fasteners. The following are typical procedures for installing heavy-duty type Dzus turnlock fasteners:

a. Punch or drill a hole in the plate or part of the assembly that is to receive the stud. The hole should be approximately the same diameter as the shank of the selected fastener. It is permissible to exceed this dimension of 1/32 inch. Remove all burrs and sand the hole smooth before dimpling or installing the grommet.

b. If the fastener to be installed is the flush type, dimple the material with dimpling dies or a female die and use a stud as the male die.

c. Insert the grommet into the hole from the bottom side, as illustrated in A view of figure 3-5.

d. Clench the grommet in place by the use of dies, as shown in the B view of figure 3-5.

e. Insert the stud into the grommet and secure it in place by the use of a block of wood and a female die, as illustrated in the C view of figure 3-5.

f. Punch a hole in the opposite piece of material approximately 3/16 inch larger than the hole punched for the stud. Remove all burrs and sand smooth the edge of the hole. Dimple the hole just enough to allow the grommet to clear when the assembly is locked together.

g. Center the spring over the hole. Mark and drill

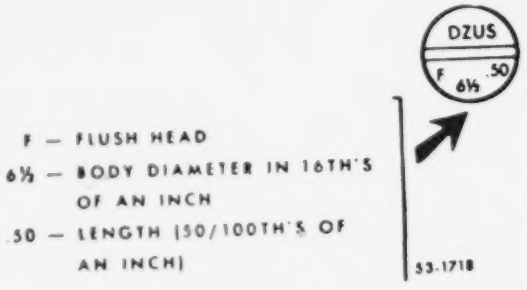


Figure 3-3. Dzus turnlock fastener head markings.

two holes for the rivets. Install the spring with countersunk rivets.

Removal procedures for heavy-duty Dzus fasteners. Very seldom will you have to remove a complete Dzus fastener assembly except in cases where a completely new type of turnlock fastener is being installed. Usually only one of the individual parts (spring or receptacle, stud, or grommet) will need replacing.

Remove broken, damaged, or worn springs or receptacles by removing the rivets securing the spring or receptacle in place. Take care not to elongate the rivet holes.

Remove the stud from the grommet by driving it from the bottom side through the grommet with a mallet. When working with thin material, provide support around the head of the stud to prevent de-

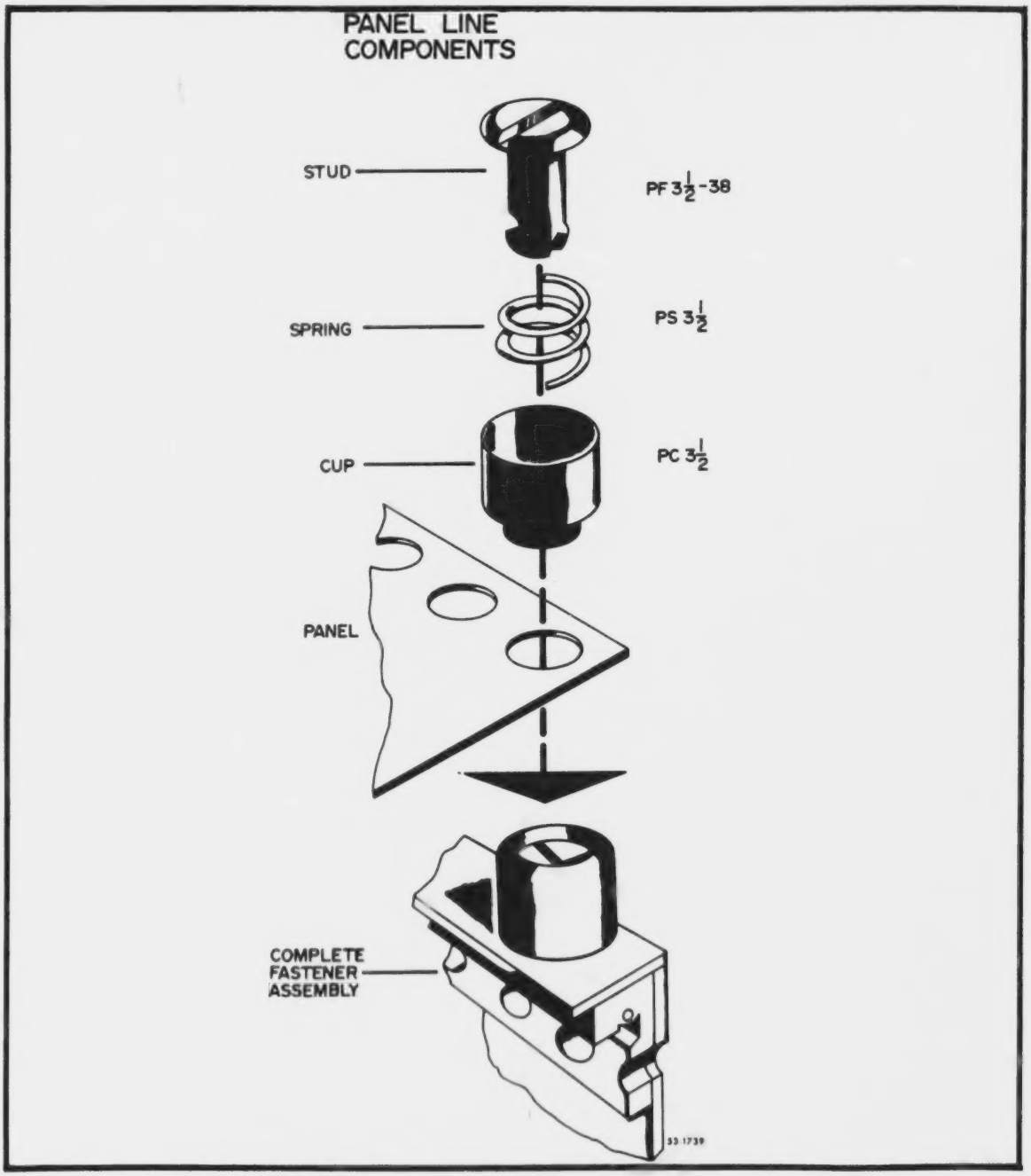


Figure 3-4. Panel line Dzus turnlock fastener.

forming the panel. If after removing the stud, the hole is too large or the dimple is deformed, remove the grommet. Then flatten the hole area, redimple the hole (if required), and install a new grommet.

Remove grommets by cutting the grommet with a chisel or similar tool. Take care not to damage the hole.

When a countersunk hole is too badly damaged to permit reinstallation of the stud, install a patch over the hole. You can install a typical patch plate by following these instructions:

1. Enlarge the hole in the panel to approximately 1/8 of an inch larger than the stud diameter.
2. Fabricate a plate approximately 1 1/2 inches square of the same material and thickness as the panel.
3. Bevel the edges of the plate.
4. Drill a hole in the center of the plate to the same diameter as the hole in the panel.
5. Dimple the hole in the plate using the stud as a male die.
6. Place the plate on the panel so that the dimple fits into the hole prepared in the panel.
7. Drill the rivet holes and secure the plate to the panel with rivets. Shop heads will need to be flush.
8. Install the grommet.
9. Install the stud.

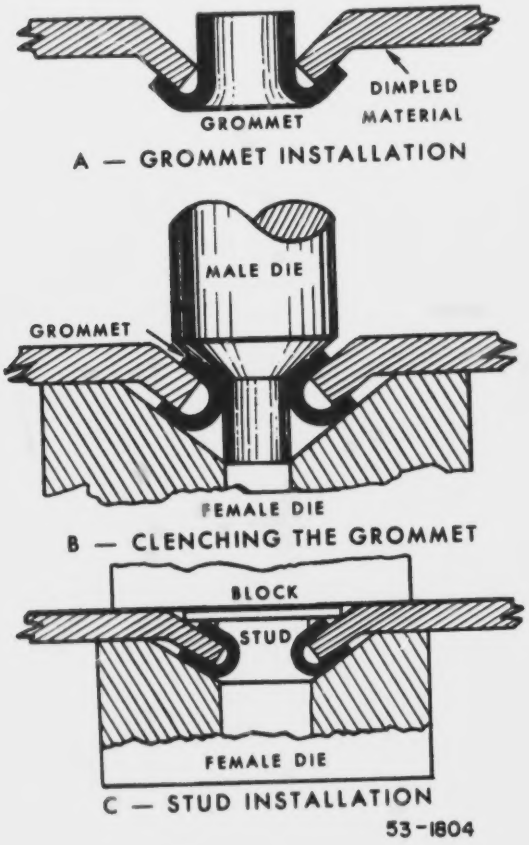


Figure 3-5. Dzus turnlock fastener grommet installation.

Exercises (632):

1. If you were installing a 1/4 diameter Dzus turnlock fastener, what is the maximum size hole you can drill in the panel for the stud?

2. Based on your answer to exercise 1, what size hole is needed on the substructure for the receptacle?

3. Based on your answer to question 1, what size hole is required in a patch plate used over a damaged countersunk Dzus fastener hole?

4. How is the locking spring for a Dzus turnlock fastener removed?

5. How is the grommet for a Dzus turnlock fastener removed?

633. Give significant details relating to the installation of light-duty type Dzus turnlock fasteners.

Installation procedures for light-duty Dzus fasteners. The light-duty type Dzus turnlock fasteners require different installation procedures from those used for the heavy-duty type. Figure 3-6 shows a Dzus assembly hand tool for on-the-spot installation. The complete fastener assembly, for the panel, is installed in one easy operation. For purposes of our discussion, the installation procedures involving the use of forming blocks and punches are described in the following steps:

- Step 1. When installing a new light-duty type fastener, drill the hole in the panel to 0.257 of an inch. Then countersink the underside of the panel to a 100° countersink. This countersunk area is necessary for swaging the cup to the panel, forming a flush surface on the underside of the panel.
- Step 2. (Refer to operation 1 in fig. 3-7.) Insert the cup into the hole. Insert into the cup a forming block with a circular protrusion equal to the inside diameter of the cup. Use this forming block to hold the cup firmly against the panel while the cup is being swaged to the panel. The forming block should be mounted in a bench vise during the installation.
- Step 3. Using a beveled forming punch, swaged the cup to the panel by lightly tapping the forming

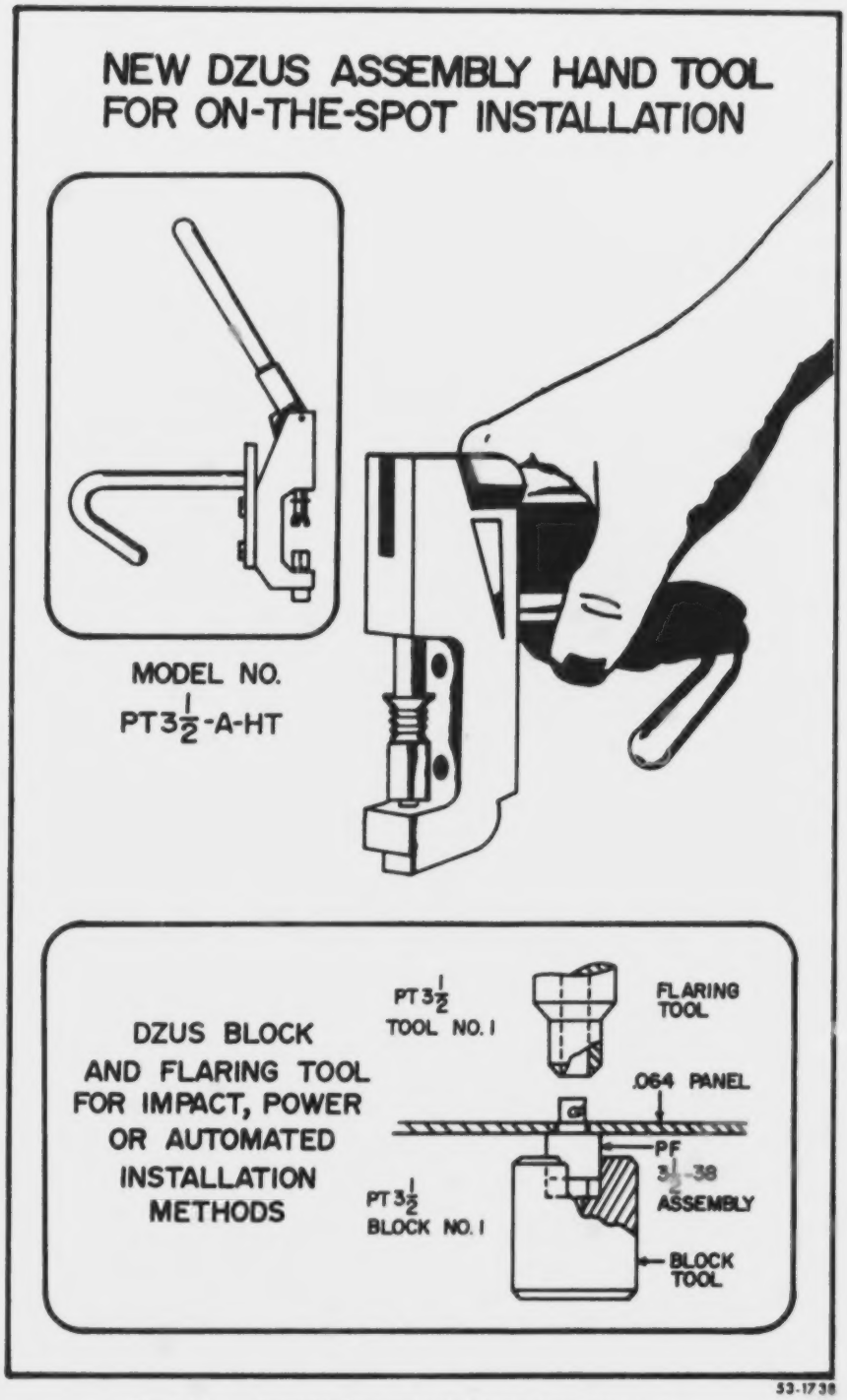


Figure 3-6. Panel line Dzus turnlock fasteners installation tool.

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punch with a soft faced mallet. (Refer to operation 2 in fig. 3-7.)

- Step 4. Once the cup is swaged to the panel, insert the spring and stud into the cup.
- Step. 5 Position a forming block, which has a hole in it slightly larger than the stud, in the bench vise. Insert the end of the stud protruding through the panel into the hole in the forming block.
- Step. 6. Using a forming punch which has a hole in it, slightly larger than the outside diameter of the cup and which is beveled at the top of the hole, form the locking collar on the cup. The locking collar is formed by positioning the forming punch on the cup, and lightly tapping the forming punch with a soft faced mallet. The locking collar retains the stud in place but yet allows the stud to be depressed for fastening. (Refer to operation 3 in fig. 3-7.)

When it is necessary to remove the stud, punch out the stud from the bottom side, insuring that some sort of support is provided on the opposite side to prevent damage to the panel. Once the stud and spring are removed, the cup can be removed (if necessary) by drilling the countersunk area of the cup. Care should be taken not to drill too deep, damaging the countersunk area of the panel. (Refer to removal operation in fig. 3-7.)

Exercises (633):

1. Why is the underside of the hole drilled for light-duty Dzus fasteners countersunk?

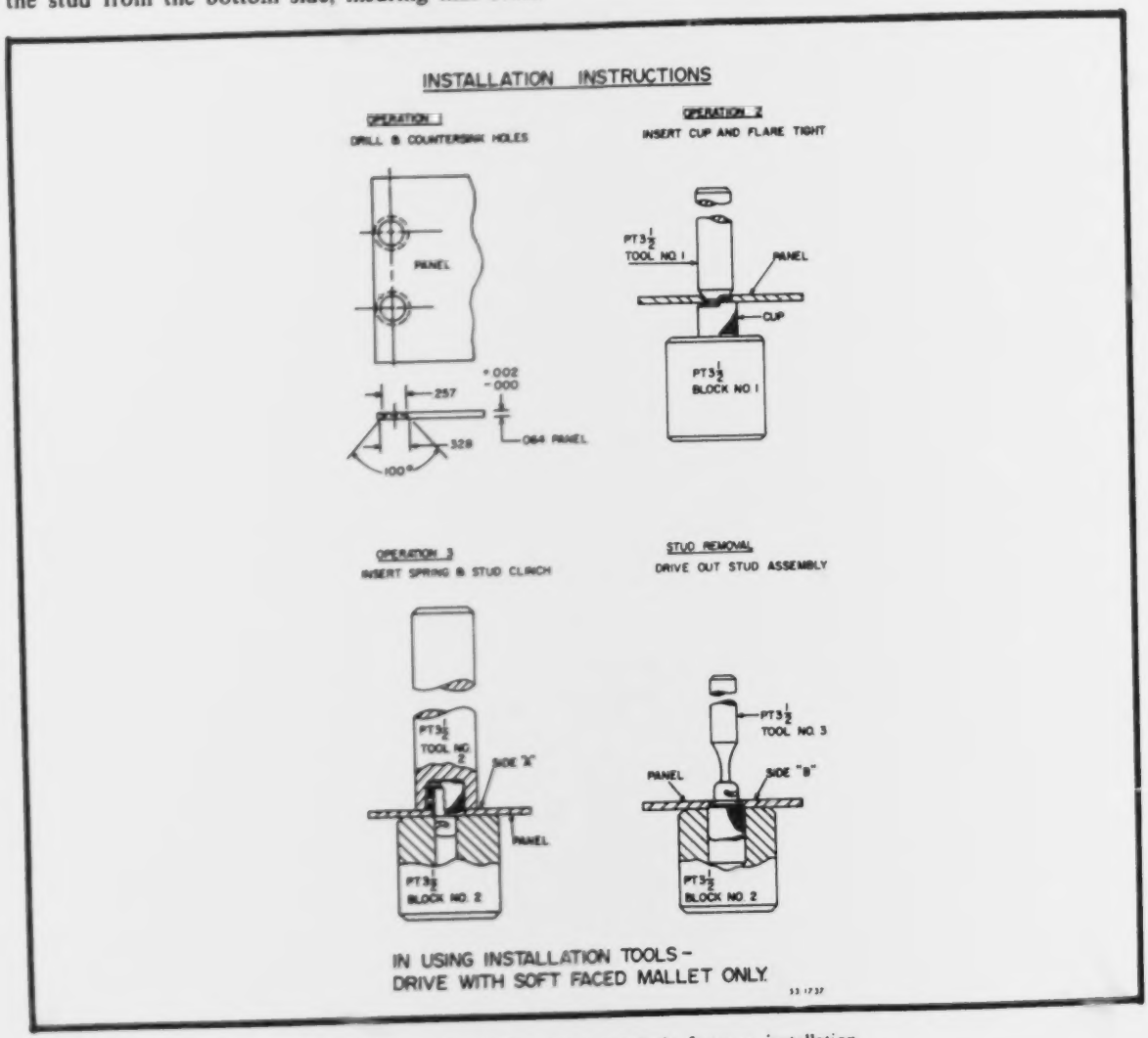

Figure 3-7. Panel line Dzus turnlock fastener installation procedure.

2. At what time, in the installation of light-duty Dzus fasteners, are the stud and spring inserted into the cup?

3. Why is it necessary to bevel the top of the up used for light-duty Dzus fasteners?

634. Identify the principal features of Camloc turnlock fasteners.

Camloc Fasteners. Camloc turnlock fasteners are made in a variety of style and designs. Included among the most commonly used are the 2600, 2700, 40551, and 4002 series. The 4002 series is shown in figure 3-8. This is the type you will use most often.

The Camloc turnlock fastener is used primarily to secure aircraft cowling, access panels, and fairings. It consists of three main parts: the stud assembly, the grommet, and the receptacle.

Stud assembly. The stud assembly, shown in figure 3-8, consists of a stud, cross pin, spring, and spring cup. It is preassembled at the factory and should never be disassembled. The stud assembly is manufactured in different lengths to accommodate different thicknesses of panels. The grip length is indicated by a number stamped on the head of the stud. The stud may be either a flush or nonflush type with a common screwdriver recess.

Grommet. There are two types of grommets, the flanged ring-type and the swage-type. The flanged ring-type, shown in figure 3-8, is available in various lengths to accommodate the different thicknesses of panels. A grommet retaining ring is used to hold the flanged ring-type in place once it is installed in the panel (see fig. 3-8).

The swage-type grommet, at first glance, looks very similar to the ring-type grommet. But a closer look will show that a soft outer sleeve is added. When installed, this outer sleeve extends through the panel and protrudes on the backside of the panel. This extra sleeve material is then swaged against the backside of the panel locking the grommet in place. Forming punches are needed to swage the sleeve material. Different lengths are available for different panel thicknesses. Both types of grommets are made to fit into a plain, dimpled countersunk or counterbored hole. The type hole to use depends on the location and thickness of the material involved. The grommet also retains the stud assembly in place. An additional stud retaining ring is sometimes used, as shown in figure 3-8, to keep the stud in place. This is an added safety feature.

Receptacle. There are two types of receptacles available: rigid and floating. The rigid receptacle is not used to a great extent on cowling. When repairs or replacement is necessary, the rigid receptacle should be replaced with a floating type. The receptacle shown in figure 3-8, consists of an aluminum alloy forging mounted in a stamped shut metal base. The forging has room for approximately 1/8 of an inch float. The receptacle is riveted to the access opening frame, which is attached to the substructure of the aircraft.

Exercises (634):
Match the following statements to the specific Camloc part, by writing in the part's name, in the spaces provided.

_____ 1. Available in a swage-type design.

_____ 2. Installed on the substructure.

_____ 3. Has a 0.125 of an inch alignment movement.

_____ 4. Consist of four parts.

_____ 5. Does not come preassembled.

_____ 6. One size used for all thicknesses of materials.

_____ 7. Contains a common screwdriver recess.

_____ 8. Type used depends on the type hole configuration.

635. Given descriptions of the installation and removal procedures used for Camloc fasteners, match each procedure to an individual part of the Camloc assembly.

Installation procedures for Camloc fasteners. When installing new Camloc assemblies, punch the holes in the panel or piece of material for flush type grommets approximately 1/32 of an inch smaller than the outside diameter of the grommet. Deburr and sand the edges smooth to avoid cracking the panel during the

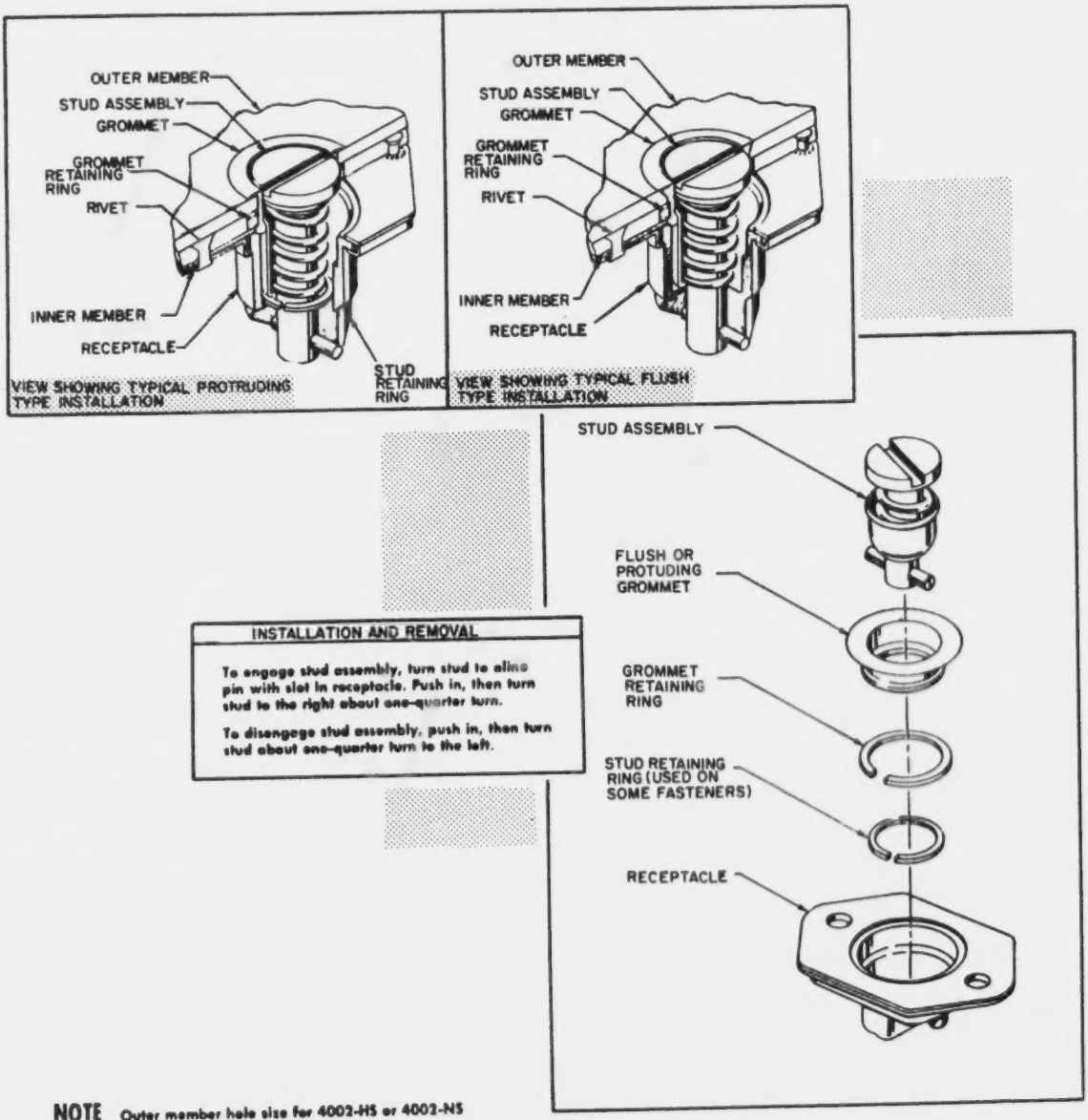
OUTER MEMBER
STUD ASSEMBLY
GROMMET
GROMMET RETAINING RING
RIVET
INNER MEMBER
RECEPTACLE
STUD RETAINING RING
VIEW SHOWING TYPICAL PROTRUDING TYPE INSTALLATION
OUTER MEMBER
STUD ASSEMBLY
GROMMET
GROMMET RETAINING RING
RIVET
INNER MEMBER
RECEPTACLE
VIEW SHOWING TYPICAL FLUSH TYPE INSTALLATION
INSTALLATION AND REMOVAL
To engage stud assembly, turn stud to aline pin with slot in receptacle. Push in, then turn stud to the right about one-quarter turn.
To disengage stud assembly, push in, then turn stud about one-quarter turn to the left.
STUD ASSEMBLY
FLUSH OR PROTUDING GROMMET
GROMMET RETAINING RING
STUD RETAINING RING (USED ON SOME FASTENERS)
RECEPTACLE
NOTE Outer member hole size for 4002-HS or 4002-NS grommet is 0.473 (+0.003, −0.002) inch.
Inner member hole size for 214-16 receptacle is 0.6875 (+0.005, −0.001) inch when used with 4002-HS or 4002-NS grommet.
53-1805

Figure 3-8. 4002 series Camloc turnlock fastener.

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dimpling operation. Select male and female dimpling dies of the correct size to dimple the hole. After the holes are dimpled, apply two coats of zinc chromate primer. Allow the first coat to dry before applying the second coat. Insert the grommet into the dimpled hole from the top and install the grommet retaining ring. This procedure results in the grommet being held securely in place.

NOTE: Swage-type grommets require different procedures as previously discussed.

Once the grommet has been installed, install the stud assembly. A special installation tool, as shown in figure 3-9, is used to install Camloc stud assemblies. To install the stud in the grommet, insert the stud onto the Camloc pliers, compress the spring, and with a twisting motion, insert the stud assembly into the grommet; then release the spring. The stud, cannot be removed unless the spring is again depressed. A stud retaining ring (if required) is installed at this time.

To install a receptacle, prepare a hole in the material the same diameter as that in the receptacle. Center the receptacle on the prepared hole and mark the rivet holes. Install the receptacle, using flush-head style rivets. Steel pull-thru blind rivets may be substituted for aluminum alloy solid shank rivets in all substructures except magnesium.

The final step necessary to complete the installation is checking to see if you have used the correct grip length stud. To lock the stud assembly into the receptacle, turn the stud to align the pin with the slot in the receptacle. Push in; then turn the stud to the right about one-quarter of a turn. The stud should not have to be forced into the locking position but should lock with a snug fit. Studs installed on aerodynamic surfaces must meet applicable aerodynamic smoothness. Studs installed on nonaerodynamic surfaces are usually limited to 0.015 of an inch above to 0.015 of an inch below the surface.

Removal procedures for Camloc fasteners. When it becomes necessary to remove and replace Camloc turnlock fasteners, procedures used are similar to those used in installation. Drill the rivet out of the receptacle and install a new one. Use Camloc pliers. Depress the spring of the stud assembly and remove the stud. Install a new one, using the previously explained procedures. If the grommet requires replacement, exercise caution in removing the damaged one. If the hole has not been damaged in removal, dimple the material again and install a new grommet using the same procedures as used in the original installation. If the hole was damaged in removal, prepare a patch plate and attach it to the material. A longer stud assembly and grommet will be required after patching.

Exercises (635):

In the space provided in front of each work procedure, place the name of the specific Camloc part that the procedure is used for.

_____ 1. A hole is punched 1/32 of an inch smaller than the part.

_____ 2. After insertion, install a retaining ring.

_____ 3. A twisting motion is required for installation.

_____ 4. A hole is punched equal to the diameter of the part.

_____ 5. Pliers are used for removal.

_____ 6. The material must be sanded and deburred prior to installation.

636. Differentiate between the various features and sizes of Airloc turnlock fasteners.

Airlock Fasteners. The standard Airloc turnlock fastener consists of a stud, a cross-pin and a stud receptacle. The Airloc is a strong, positive locking fastener that is easily detected when unlocked. Figure 3-10 shows the three separate parts and their corresponding part numbers.

Stud. The studs are manufactured from case-hardened steel to prevent excessive wear. Studs are available in different lengths, diameters, and head styles. The total thickness of material that a specific stud will satisfactorily lock together is stamped on the

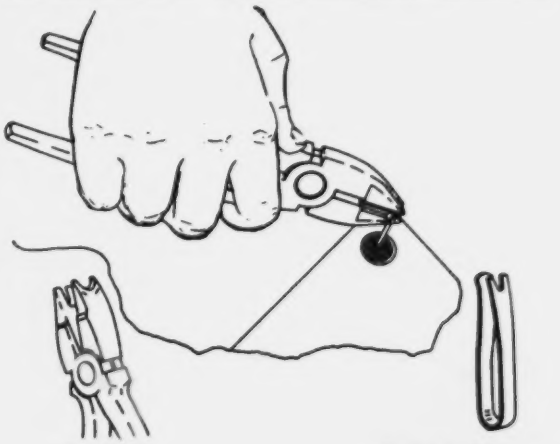


Figure 3-9. Camloc installation tools.

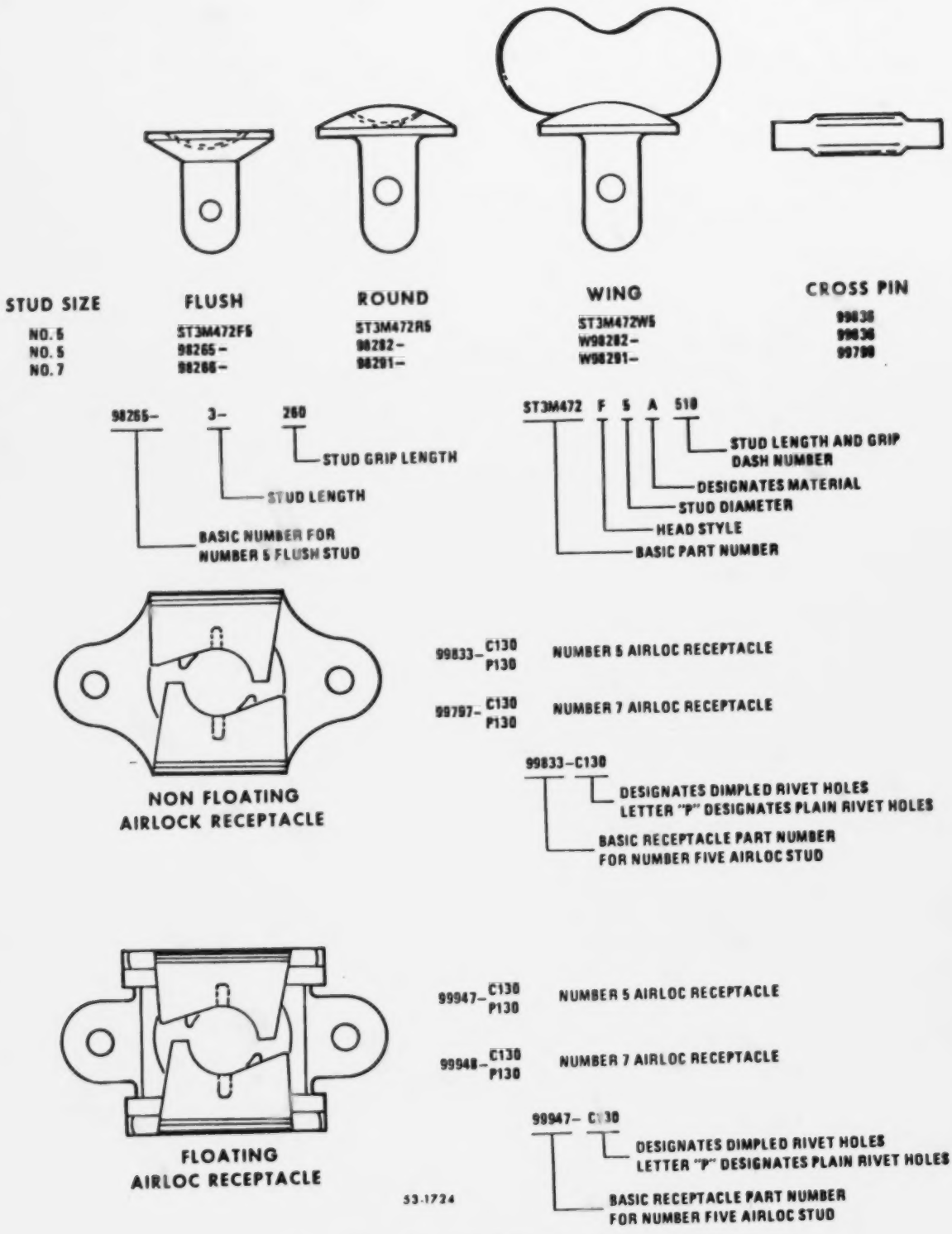


Figure 3-10. Airloc turnlock fastener identification data.

690

head of the stud in thousandths of an inch (.040, .070, .190, etc.). Studs are available in three head styles: flush, oval, and wing, as shown in figure 3-10. The stud hole is reamed for a press fit of the crosspin in the stud hole.

Cross-pin. The cross-pin, illustrated in figure 3-10, is manufactured from chrome-vanadium steel and is heat-treated to provide maximum strength, wear, and holding power. It should never be used the second time; once removed from the stud, it should be replaced with a new cross-pin.

Receptacles. Receptacles for Airloc turnlock fasteners, as you can see from figure 3-10, are manufactured in two types; nonfloating and floating. The size designation of receptacles is based on the distance between the receptacle rivet holes and their relative tensile strengths. Receptacle sizes are classified by numbers: number 1, number 2, number 5, and number 7. The center-to-center distance between the rivet holes of the different sized receptacles are:

- Number 1 - .500 (1/2)
- Number 2 - .775 (3/4)
- Number 5 -1.000 (1)
- Number 7 -1.375 (1⅜)

Figure 3-11, shows the related studs and cross-pin associated with the numbered receptacle. Figures 3-12 and 3-13, show the related hardware for the number 2 and number 5 receptacles.

Both types of receptacles are manufactured from high carbon heat-treated steel. An upper wing provides ejection of the stud when the fastener is unlocked and permits the cross-pin to be held in a locked position between the upper wing, the cam, the stop, and the wing detent, regardless of the tension to which the receptacle is subjected. The receptacle is fastened to the inner surface of the inner sheet to which it is to be attached.

Execises (636):

1. An Airloc fastener receptacle that has a rivet spacing of 1 inch, is what numbered Airloc?

2. How can you determine the grip length of an Airloc stud?

3. Which of the Airloc fastener parts is fabricated from high carbon steel?

4. What factor separates the types of Airloc receptacles?

5. What part of an Airloc fastener is fabricated from chrome-vanadium steel to provide maximum strength?

637. Given a listing of situations involving the installation and removal of Airloc turnlock fasteners, determine the correct work procedure to use.

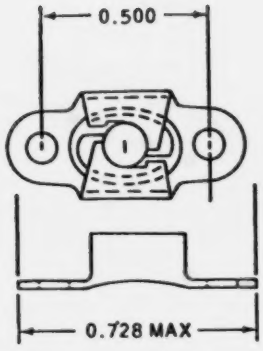
Installation procedures for Airloc fasteners. To install a flush-type Airloc turnlock fastener, first prepare the hole for the stud. The size of the punched hole should be approximately the same as the diameter of the stud shank. Remove all burrs from the edge of the hole and sand smooth before dimpling. Select the correct size male and female dimpling dies and dimple the hole. Apply two coats of zinc-chromate primer, allowing the first coat to dry before applying the second coat. The dimple should be deep enough to accommodate the head of the stud.

To determine the proper grip length, you must consider the type receptacle being used. For nonfloating type receptacle, measure the thickness of the material through which the stud passes in thousandths of an inch and add 0.010 of an inch. Take the nearest 0.010 of an inch above this total to find the proper grip length. For floating receptacles, add 0.020 of an inch for number 2 receptacles, 0.030 for number 5 and 7 receptacles, to the total material thickness. Then take the nearest 0.010 inch above this total to find the proper grip length.

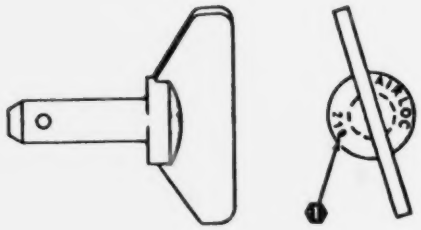
After the hole has been prepared and the correct grip length selected, insert the stud into the dimpled hole. Select the proper sized crosspin installation pliers based on the diameter of the stud, and install the cross-pin. The cross-pin must protrude equally on both sides of the stud.

Receptacle installation involves punching a hole in the material large enough to accommodate the dimple of the stud hole. Center the receptacle to the hole. Locate and mark the center of the holes for the rivets. Center punch, drill, and countersink the rivet holes. Install the receptacle with countersunk rivets. Steel pull-thru blind rivets may be substituted for aluminum alloy solid shank rivets in all substructures except magnesium.

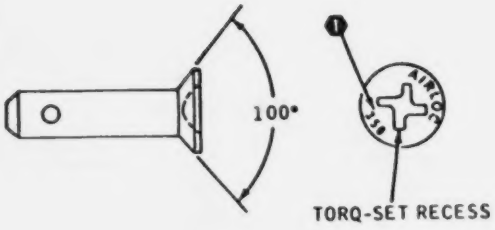
The final step involves checking the alignment and fastening the Airloc stud. When an Airloc stud does not fasten properly and the stud length is known to be correct, excess misalignment is usually the cause. This condition can often be corrected by removing the panel and fastening the studs in a different sequence, either by fastening the difficult studs first or by starting in the middle of the panel and working toward each end. Sometimes a severe warpage or wrinkling of a panel makes it difficult to engage the receptacle, a longer stud length of an additional 0.010 or 0.020 of an inch may be required. In an extreme case of misalignment, a slightly larger stud hole may correct the



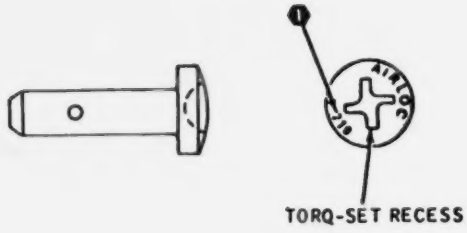
RECEPTACLE 294420-P. 098



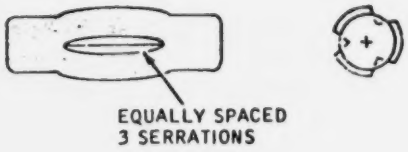
STUD 294423-( )-( )



CSK STUD 294427-( )-( )



ROUND HEAD STUD 294428( )-( )



CROSS PIN 294424

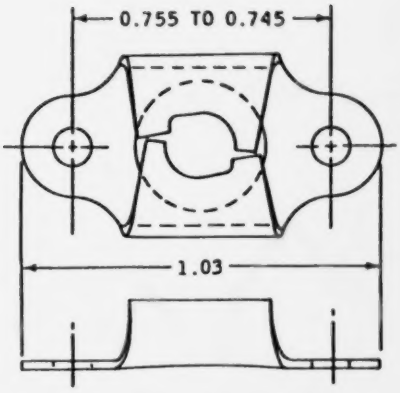
53-1734

Note

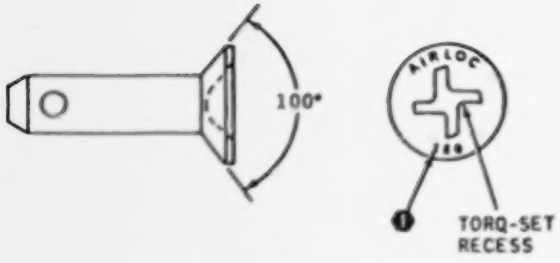
❶ NUMBER STAMPED ON HEAD OF STUD INDICATES MAXIMUM MATERIAL THICKNESS TO BE FASTENED (2ND DASH NO.).

Figure 3-11. Number 1 Airloc turnlock fastener data.

692

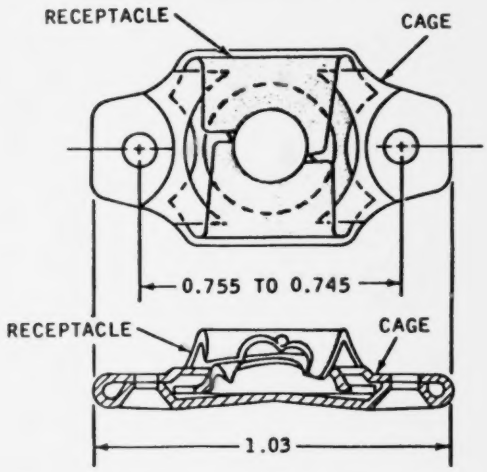


STATIONARY RECEPTACLE
293059-P098 PLAIN HOLES
293059-C098 CSK HOLES

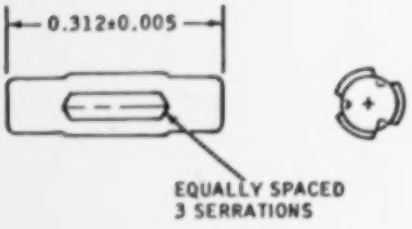


CSK STUD 293278-( )-( )

ROUND HEAD STUD 112015-( )-( )



FLOATING RECEPTACLE
293045-C098



❷ CROSS PIN 293279

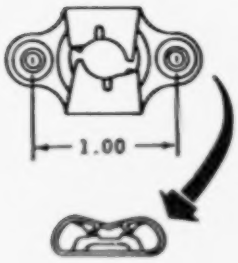
Note

❶ NUMBER STAMPED ON HEAD OF STUD INDICATES MAXIMUM MATERIAL THICKNESS TO BE FASTENED (2ND DASH NO.).

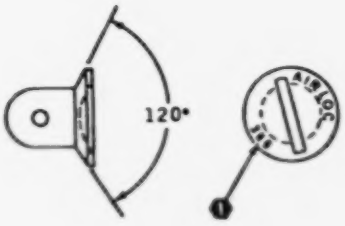
❷ THIS ASSEMBLY IS FOR HIGH-STRENGTH APPLICATIONS. CROSS PIN IS NOT INTERCHANGEABLE WITH LOW-STRENGTH TYPES.

53-1733

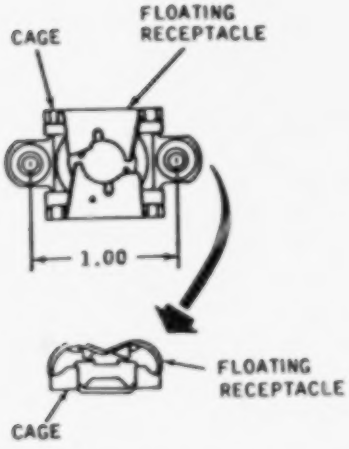
Figure 3-12. Number 2 Airloc turnlock fastener data.



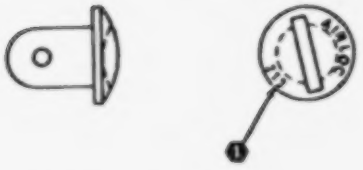
STATIONARY RECEPTACLE
99833-C130 CSK HOLES
99833-P130 PLAIN HOLES



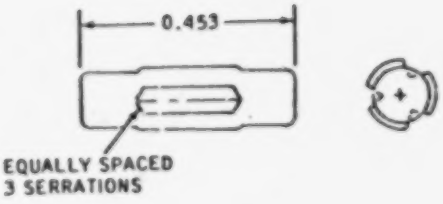
CSK STUD 98265-( )-( )



FLOATING RECEPTACLE
99947-C130 CSK HOLES
99947-P130 PLAIN HOLES



ROUND HEAD STUD 98292-( )-( )



CROSS PIN 99836

Note

❶ NUMBER STAMPED ON HEAD OF STUD INDICATES MAXIMUM MATERIAL THICKNESS TO BE FASTENED (2ND DASH NO.).

53-1734

Figure 3-13. Number 5, Airlock turnlock fastener data.

condition. However, care must be used so that the stud holes do not exceed 27/64 of an inch for the number 7 stud, 5/16 of an inch for a number 5 stud, and 7/32 of an inch for the number 2 stud; otherwise the stud will fall out of the panel. If a rigid type receptacle is being used, a floating type may correct the condition.

When floating type receptacles are used, it is necessary to enlarge the receptacle hole to 7/8 of an inch for the number 7 receptacle, 11/16 of an inch for the number 5 receptacle, 15/32 of an inch for the number 2 receptacles. This will permit maximum float or misalignment takeup. When tightening Airloc studs, do not hammer the stud head because the cross-pin may fracture the cam of the receptacle. Be sure the cross-pin is centered in the stud.

Removal procedures for Airloc fasteners. You can remove airlock fastener assemblies by using the correct size Airloc pliers to remove the cross-pin, and then removing the stud. Remove the receptacle by drilling out the rivets. Take care not to damage the rivet holes.

Exercises (637):
Match the work procedure in column 2, with an installation and removal situation stated in Column 1, by placing the letter of the work procedure in the space provided in Column 1.

Column 1	*Column 2*
1. _____ Hole for stud in access panel.	*a.* Add 0.010 or 0.020 to stud length.
2. _____ Hole for receptacle in substructure.	*b.* Select pliers equal to the diameter of the stud.
3. _____ Determining grip length of a #5 Airloc stud.	*c.* Enlarge panel hole to 15/32 of an inch.
4. _____ Cross-pin removal.	*d.* Reinstall studs in a different locking sequence.
5. _____ Location of rivet holes for receptacles.	*e.* Hole is punched to same diameter as the stud diameter.
6. _____ Eliminating extreme misalignment of #2 Airloc studs	*f.* Hole is punched to the required diameter based on the head style of the stud.
7. _____ Panel is warped or wrinkled badly.	*g.* Center receptacle over hole in substructure.
8. _____ Correct length Airloc studs will not lock.	*h.* Add material thicknesses plus 0.030 of an inch.

3-2. Structural Turnlock Fasteners

Structural turnlock fasteners differ from the nonstructural turnlock fasteners in that they are designed to be a stress-carrying member of the assembly of which they are a part.

Since they are stress-carrying fasteners, every effort must be made by you to insure that maximum strength requirements are obtained when they are fastened. The structural turnlock fasteners discussed in this section are just a few of the many types in use today. A knowledge of the highstress Camloc, Milson, Deutsch Zip-Loc, and Calfax turnlock fasteners, will enable you to understand the principles and purposes of the individual parts of structural turnlock fasteners not covered in this section. When you are faced with a work situation involving an unknown type of turnlock fastener, consult the specific -3 TO.

638. Distinguish between true and false statements related to the structural Camloc turnlock fasteners.

High-Stress Camloc Fasteners. Camloc quick-acting structural turnlock fasteners, figure 3-14, consist of three parts: the stud assembly, the retaining ring, and the receptacle. The stud is held in the access panel or door by the retaining ring, and the receptacle is riveted to the substructure.

Stud assembly. The stud assembly consists of a stud with either a protruding or countersunk head style, a tension spring, and a countersunk hollow sleeve. The stud assembly comes from the manufacturer preassembled. A number stamped on the head of the stud indicates grip length. You must consult a grip range chart to determine the minimum and maximum thicknesses that can be properly fastened with a specific length.

Retaining ring. The retaining ring is circular in shape and is locked on the outside of the stud assembly sleeve, after the stud assembly is inserted into the hole in a panel or door. On the inside area of the retaining ring are notches that must be aligned with the grooves on the stud assembly, as shown in figure 3-14. Retaining rings are fabricated in both flat and cone shaped designs. The flat retaining ring is used when the stud holes are countersunk. The coned shaped retaining rings are used when the stud holes are dimpled.

Receptacle. The receptacle assembly consists of an adjustable threaded insert, a rivet attachment assembly, and an outer cover. The adjustable threaded insert engages the stud during the fastening process. The rivet attachment assembly forms a housing for the threaded insert, and contains the rivet holes for attaching the receptacle to the material. The rivet attachment assembly also acts as a stop, preventing the threaded insert housing from rotating, when you are tightening the stud. The cover unit acts as a dust cover, preventing foreign objects from getting into the receptacle from the backside. Also the cover prevents the threaded insert from being completely unthreaded from the receptacle.

Installation procedures. Holes drilled for the stud assembly require a letter W (0.3860) twist drill. For dimpled holes, use a 19/32 of an inch drill for predrilling before dimpling. Then for the final hole size use the letter W twist drill. Receptacle hole preparation will depend on the type holes used in the access

panel or door. The hole size should be the same as the stud hole. Panels or doors having countersunk holes and using flat retaining rings, must be counterbored. The counterbore is needed to provide a recess for the retaining ring when the panel is installed. For panels having dimpled holes, subcountersinking of the substructure is necessary to provide a flush fit when the panel is fastened in place. For receptacle installation, follow the procedures previously discussed for nonstructural turnlock fastener receptacles.

NOTE: When the total thickness of the material being fastened is less than 0.158 of an inch, a shim is required under the receptacle.

Fastening procedure. After the individual parts have been installed, the final installation procedure involves fastening the fastener. Factors such as hole alignment, grip length, receptacle operation, and smoothness requirements are checked. To engage the stud assembly, push the stud in and turn it right one-quarter of a turn. If the stud does not rotate freely for

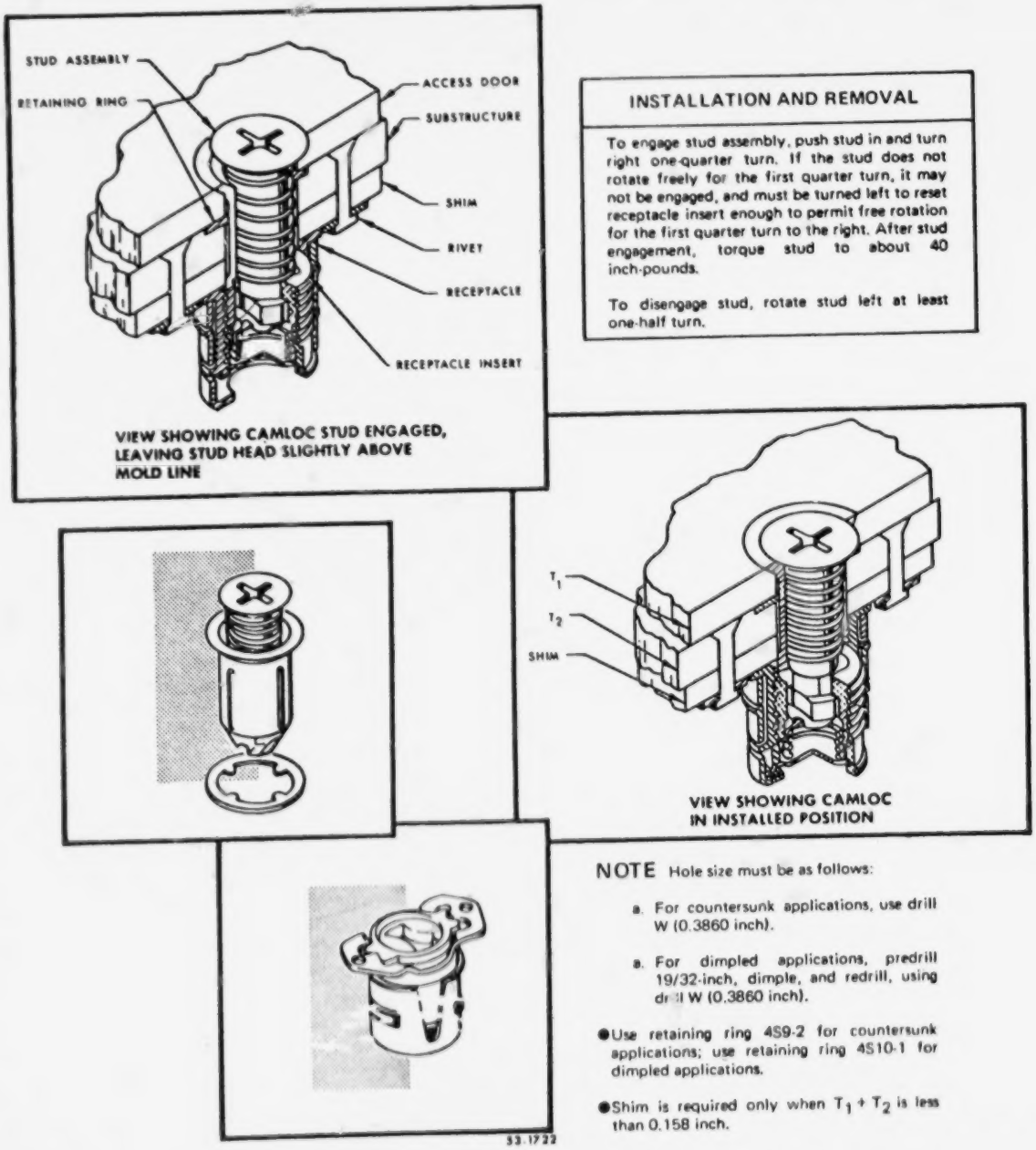

STUD ASSEMBLY
RETAINING RING
ACCESS DOOR
SUBSTRUCTURE
SHIM
RIVET
RECEPTACLE
RECEPTACLE INSERT
VIEW SHOWING CAMLOC STUD ENGAGED, LEAVING STUD HEAD SLIGHTLY ABOVE MOLD LINE
INSTALLATION AND REMOVAL
To engage stud assembly, push stud in and turn right one-quarter turn. If the stud does not rotate freely for the first quarter turn, it may not be engaged, and must be turned left to reset receptacle insert enough to permit free rotation for the first quarter turn to the right. After stud engagement, torque stud to about 40 inch-pounds.
To disengage stud, rotate stud left at least one-half turn.
T1
T2
SHIM
VIEW SHOWING CAMLOC IN INSTALLED POSITION
NOTE Hole size must be as follows:
a. For countersunk applications, use drill W (0.3860 inch).
a. For dimpled applications, predrill 19/32-inch, dimple, and redrill, using drill W (0.3860 inch).
●Use retaining ring 4S9-2 for countersunk applications; use retaining ring 4S10-1 for dimpled applications.
●Shim is required only when T1 + T2 is less than 0.158 inch.
53.1722

Figure 3-14. Structural Camloc turnlock fastener.

the first quarter turn, it may not be engaged, and must be turned left to reset the receptacle's threaded insert. The resetting involves rotating the threaded insert to the top of the receptacle. Once the stud engages the threaded insert, torque the stud to about 40 inch-pounds. To disengage the stud, rotate the stud to the left at least one-half turn.

Exercises (638):
In the space provided in front of each statement, place the letter T for true statement and the letter F for false statements. All statements are related to the structural Camloc fastener.

_____ 1. The parts that makeup a structural Camloc consist of a stud, grommet, retaining ring and receptacle.
_____ 2. A number stamped on the head of the stud indicates grip length.
_____ 3. The type hole in the access panel will determine the type retaining ring to install.
_____ 4. The receptacle assembly consists of an adjustable threaded insert and an outer cover.
_____ 5. Holes drilled for a stud assembly must be equal to the diameter of the stud.
_____ 6. Counterboring of the substructure is required when the hole for the stud in the access panel is countersunk.
_____ 7. A shim is required, under the receptacle, when the material thickness is less than 0.158 of an inch.
_____ 8. The rivet attachment assembly of the receptacle prevents the threaded insert housing assembly from rotating.
_____ 9. The grip length of the stud required, depends on the number of threads on the threaded insert assembly within the receptacle.
_____ 10. Camloc studs are torqued to 40 inch-pounds.

639. Give significant details about the structure of the Milson turnlock fasteners and their installation.

Milson Fasteners. The Milson fastener is a quick release type fastener used primarily on structural access doors. Milson fasteners consist of a sleeve bolt, a retaining ring, and a receptacle. The sleeve bolt is retained in the door or panel by the retaining ring which is expanded over the sleeve bolt. The receptacle is mounted in a permanent position on the structure and locks the sleeve bolt in place. The Milson fastener allows freedom in transferring structural loads directly through access panels. Gaps up to 0.125 of an inch can be closed with this fastener, and hole misalignment up to 0.040 of an inch still allows fastener installation.

Sleeve bolts. Sleeve bolts, as shown in figure 3-15, are available in two head styles—the pan head (protruding) and the flush head. The head of the sleeve bolt has a hex-shaped recess for insertion of an Allen wrench for installation and removal. Internal threads are built into the shank portion of the sleeve bolt. These threads permit the sleeve bolt to be screwed into the receptacle, forming a strong structural joint. The lower end of the sleeve bolt has a small protruding lip that keeps the retaining ring from falling off the sleeve bolt, once installed.

Retaining ring. Retaining rings, as shown in figure 3-15, are grooved on both sides and may be positioned in either direction on the sleeve bolt. Retaining rings are distinguished in size by the number of notches on the rings. The –4 and –5 rings used for 3/16 and 1/4 of an inch diameter sleeve bolts, have seven notches. The –6 ring, used with the 5/16 of an inch sleeve bolt, has eight notches.

Receptacles. Receptacles, as shown in figure 3-15, are available in sealing and nonsealing styles. The sealing rceptacle has located around its base an O ring which seals against a closed door or panel. For corner installation a corner receptacle is used for ease of installation. The receptacle contains a nonrotating threaded stud on which the sleeve bolt is threaded.

Shims. Shims, as shown in figure 3-16, are used in certain installations as a housing for the retaining ring. They are installed either on the inside of the panel or door, or on top of the door or panel sill. The shims are available in different styles to match the styles of receptacles.

Installation procedures. The installation procedures, that you will use, are based on the positioning of the retaining ring. Figure 3-17 illustrates four different procedures. Installation procedure I, figure 3-17, shows that the substructure is counterbored for the retaining ring. Installation procedure II, figure 3-17, illustrates that the underside of the access panel or door has been counterbored for the retaining ring and a shim has been added. Installation III, figure 3-17, indicates that the underside of the access panel has been counterbored. And the final procedure, number IV on figure 3-17, shows where both the underside of the access panel or door and the top of the substructure have been counterbored. Holes drilled for the sleeve bolt, both in the access panel or door and the substructural member, should produce a close fit. Final hole sizes are as follow:

Diameter	*Hole Size*
-4	0.252 + .007/-.000
-5	0.314 + .007/-.000
-6	0.377 + .007/-.000

To install the retaining ring, a special installation tool, NST-199 is required, as shown in the center section of figure 3-18. A color code is used to identify the

installation tool for each diameter sleeve bolt. Yellow is used for the -4 diameters, blue for -5 diameters, and red for the -6 diameters. When using the NST-199 installation tool, position the tapered shank end into the end of the sleeve bolt. Using the thumb and index finger, slide a retaining ring over the end of the tool onto the sleeve bolt.

When it is necessary to replace a retaining ring under a shim, use a pointed scriber or a similar tool to probe the damaged ring from under the shim. Using your fingers, carefully feed a new retaining ring under the shim into the counterbored recess. A limited amount of ring expansion may be necessary to install the ring. The lower portion of figure 3-18 indicates the expansion limits. Once the retaining ring is in place, screw the removal tool, shown in the top section of figure 3-18 onto the sleeve bolt. Insert the sleeve bolt, with the removal tool attached into the hole. The tapered point of the removal tool will spread the retaining ring and allow the sleeve bolt to be inserted.

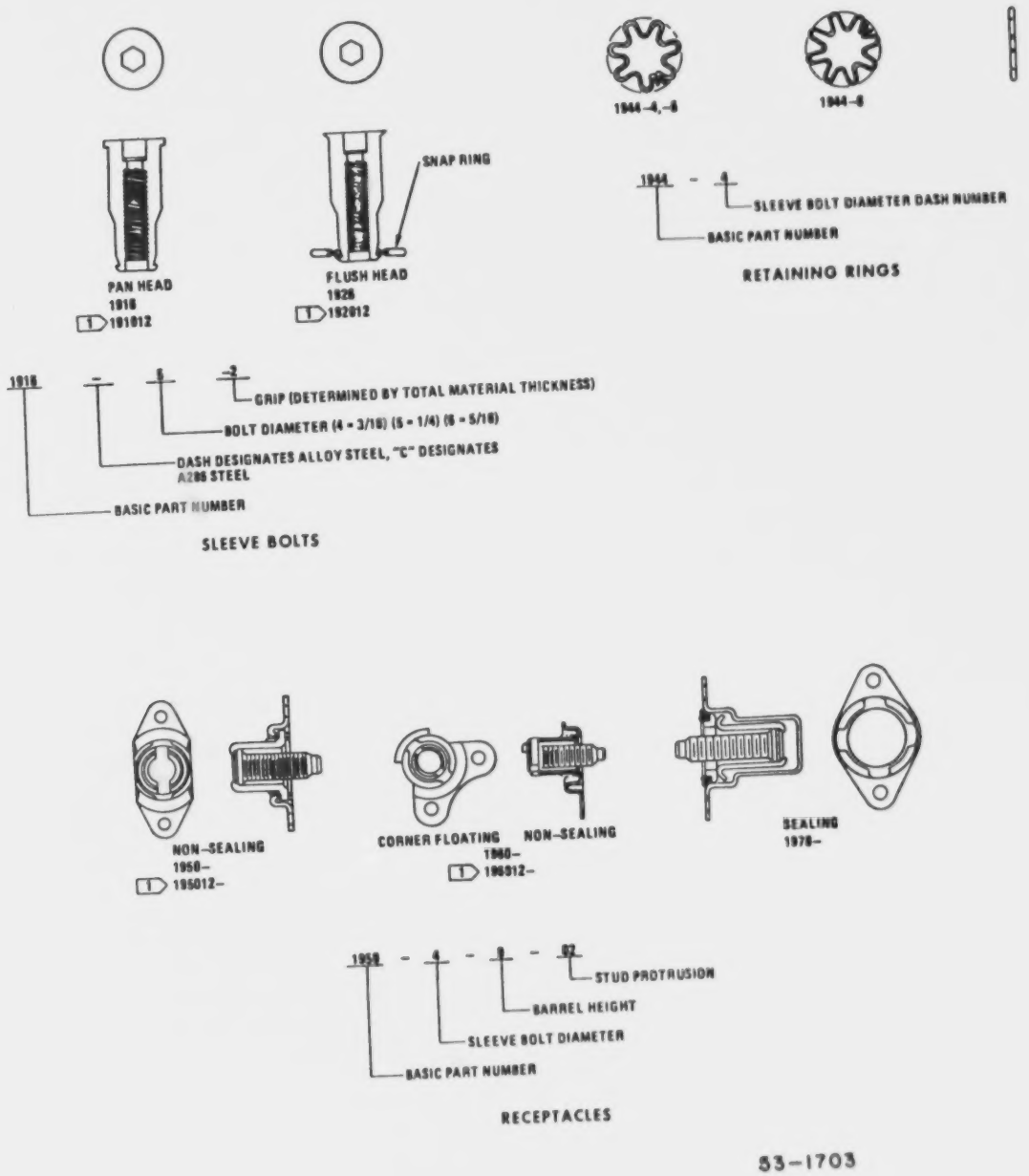


Figure 3-15. Milson turnlock fastener parts.

Once the sleeve bolt has been completely inserted, remove the removal tool. Sleeve bolts are also removed with this removal tool.

Exercises (639):

1. Name the parts that make up a Milson fastener assembly.

2. What type of wrench is needed to torque Milson fasteners?

3. If you were handed two different retaining rings for Milson sleeve bolts, which one would you select to use with a 5/16 of an inch diameter bolt?

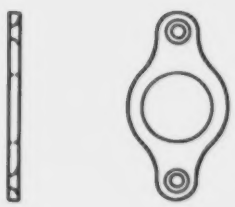
4. For what purpose are shims sometimes used with Milson fasteners?

5. How are the different installation tools for installing retaining rings distinguished?

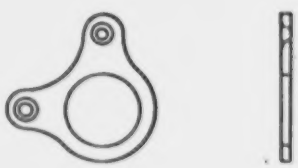
640. Cite characteristic features of the Deutsch Zip-Loc fastener which distinguish this turnlock fastener from a Milson fastener.

Deutsch Zip-Loc fasteners. Deutsch Zip-Loc fasteners, as shown in figure 3-19, are quick-acting structural-type fasteners which have excellent strength characteristics. They are used in areas of the aircraft for structural access panels and doors which are frequently removed. The basic parts are a stud, a retaining ring, and a receptacle.

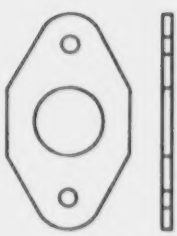
Stud. The stud is fabricated from alloy steel with a cadmium-plated finish. The head of the stud has a 7/32 of an inch hex-shaped recess. This recess permits the use of an Allen wrench when installing and removing the stud. The grip length of the stud is indicated by a number stamped at the bottom of the recess. The shank portion of the stud has internal threads which engage the threaded stud inside the receptacle. The bottom edge of the stud has serrations which grip a set of corresponding serrations in the receptacle during installation. A ring retaining lip is also incorporated on the bottom section of the stud.



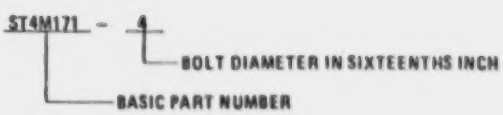
ST4M171



ST4M172



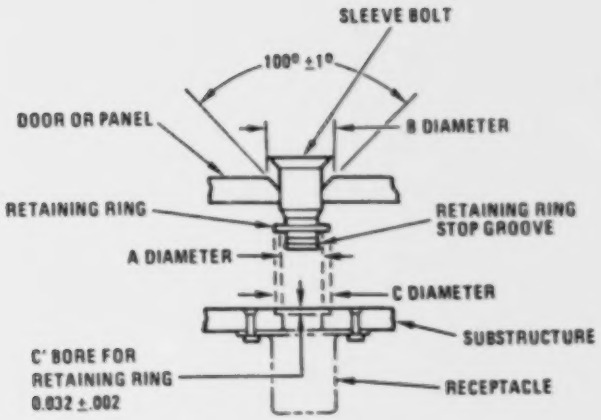
3M384



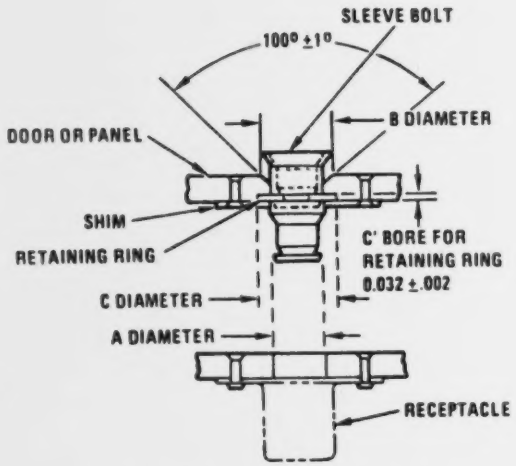
SHIMS

53-1704

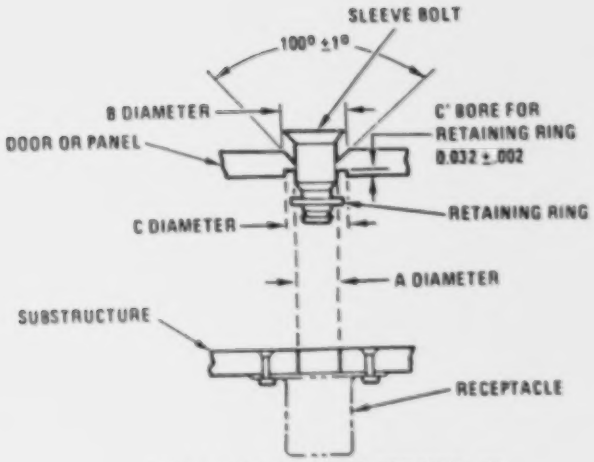
Figure 3-16. Milson turnlock fastener shims.



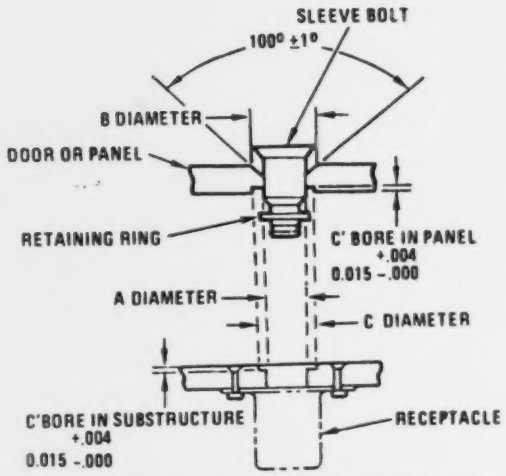
INSTALLATION PROCEDURE I



INSTALLATION PROCEDURE II



INSTALLATION PROCEDURE III



INSTALLATION PROCEDURE IV

53-1705

Figure 3-17. Milson turnlock fasteners installation procedures.

700

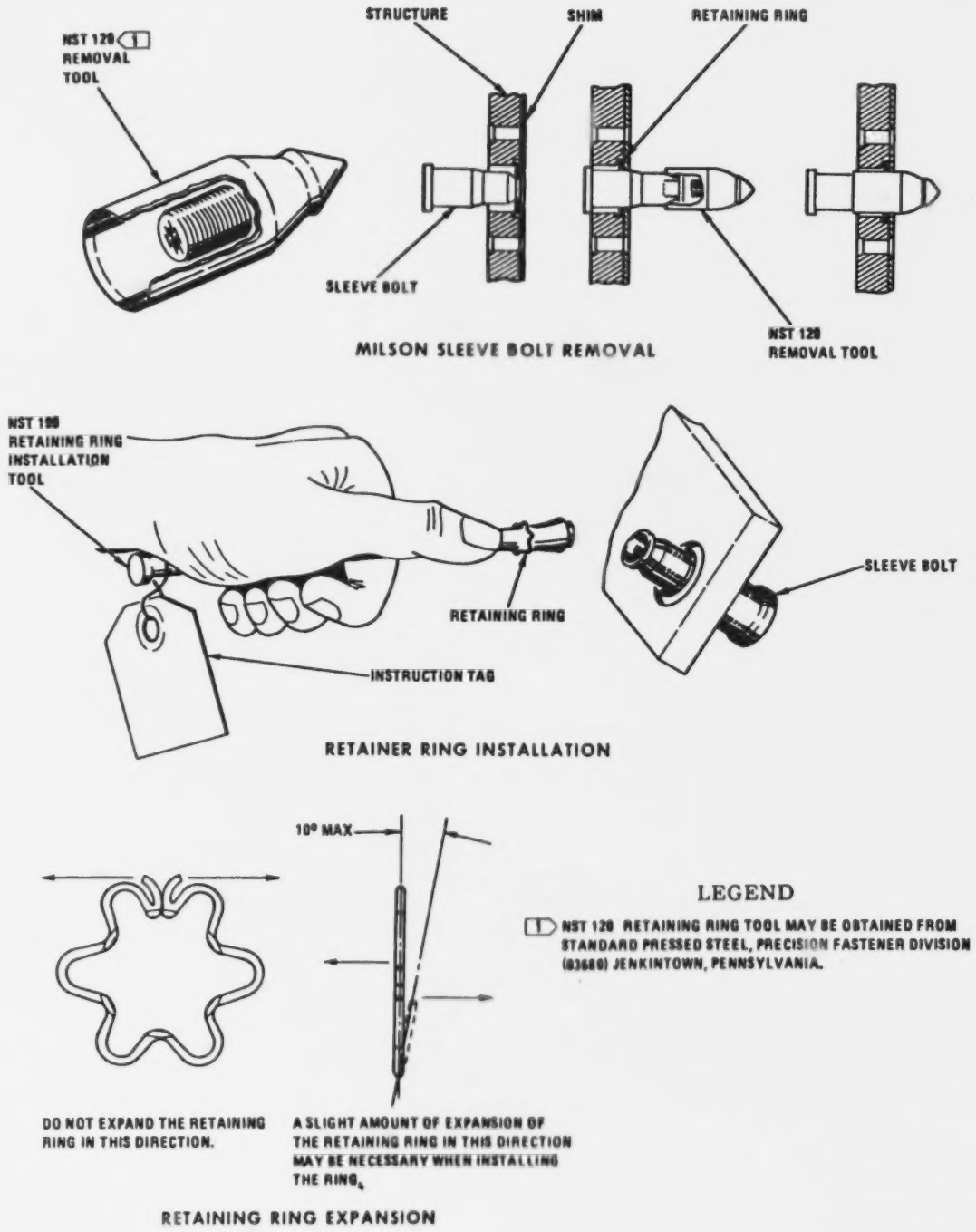

NST 120 (1) REMOVAL TOOL
STRUCTURE
SHIM
RETAINING RING
SLEEVE BOLT
NST 120 REMOVAL TOOL
MILSON SLEEVE BOLT REMOVAL
NST 198 RETAINING RING INSTALLATION TOOL
RETAINING RING
SLEEVE BOLT
INSTRUCTION TAG
RETAINER RING INSTALLATION
10° MAX
LEGEND
(1) NST 120 RETAINING RING TOOL MAY BE OBTAINED FROM STANDARD PRESSED STEEL, PRECISION FASTENER DIVISION (03680) JENKINTOWN, PENNSYLVANIA.
DO NOT EXPAND THE RETAINING RING IN THIS DIRECTION.
A SLIGHT AMOUNT OF EXPANSION OF THE RETAINING RING IN THIS DIRECTION MAY BE NECESSARY WHEN INSTALLING THE RING.
RETAINING RING EXPANSION
53-1706

Figure 3-18. Milson turnlock fasteners installation data.

701

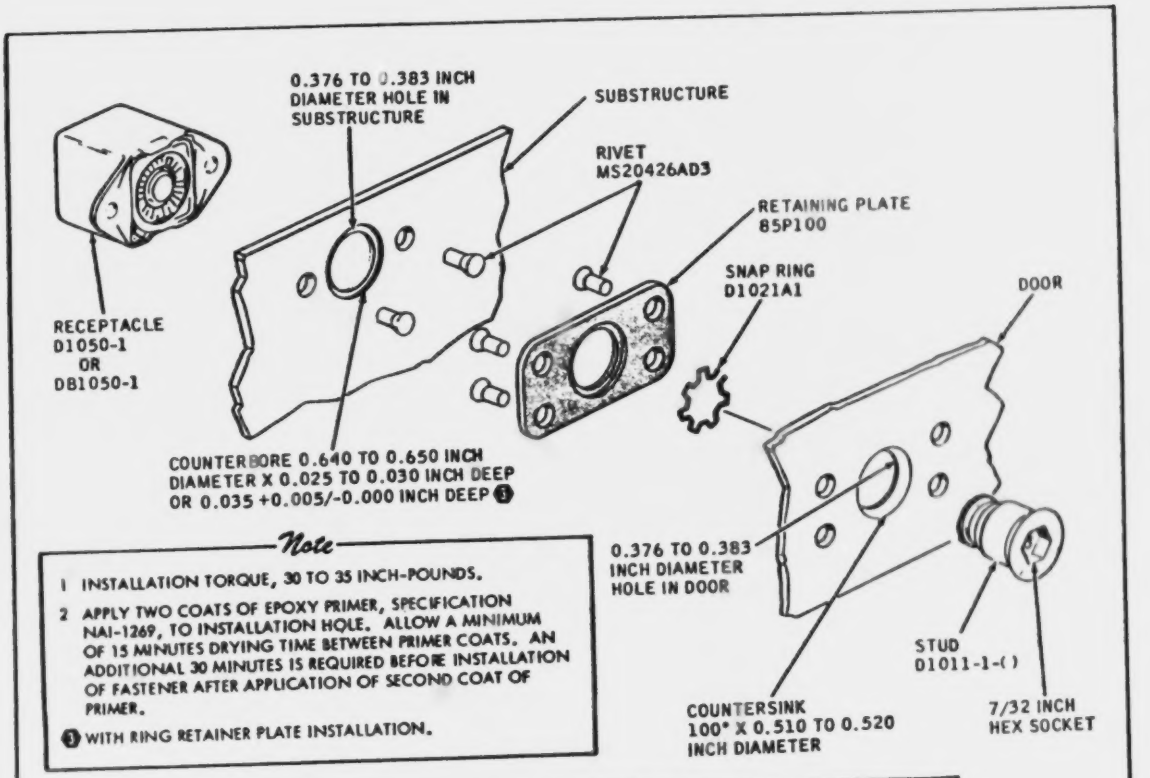
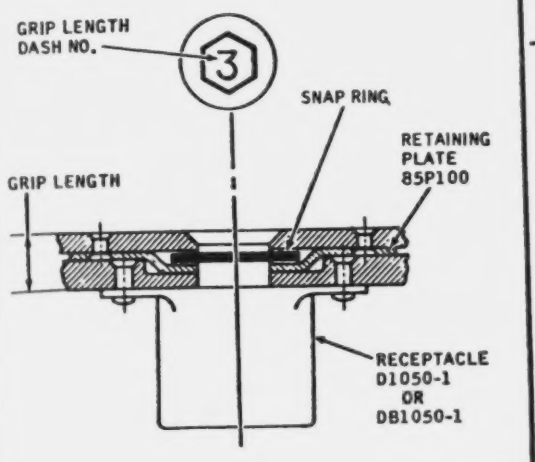

0.376 TO 0.383 INCH DIAMETER HOLE IN SUBSTRUCTURE
SUBSTRUCTURE
RIVET MS20426AD3
RETAINING PLATE 85P100
SNAP RING D1021A1
DOOR
RECEPTACLE D1050-1 OR DB1050-1
COUNTERBORE 0.640 TO 0.650 INCH DIAMETER X 0.025 TO 0.030 INCH DEEP OR 0.035 +0.005/-0.000 INCH DEEP ❸
0.376 TO 0.383 INCH DIAMETER HOLE IN DOOR
STUD D1011-1-( )
COUNTERSINK 100° X 0.510 TO 0.520 INCH DIAMETER
7/32 INCH HEX SOCKET
Note
1 INSTALLATION TORQUE, 30 TO 35 INCH-POUNDS.
2 APPLY TWO COATS OF EPOXY PRIMER, SPECIFICATION NAI-1269, TO INSTALLATION HOLE. ALLOW A MINIMUM OF 15 MINUTES DRYING TIME BETWEEN PRIMER COATS. AN ADDITIONAL 30 MINUTES IS REQUIRED BEFORE INSTALLATION OF FASTENER AFTER APPLICATION OF SECOND COAT OF PRIMER.
❸ WITH RING RETAINER PLATE INSTALLATION.

CHART A – STUD D1011-1-( )



D1011-1-( ) STUD	
LAST DASH NO.	GRIP LENGTH
1	0.062 TO 0.125
2	0.125 TO 0.188
3	0.188 TO 0.250
4	0.250 TO 0.312
5	0.312 TO 0.375
6	0.375 TO 0.438
7	0.438 TO 0.500
8	0.500 TO 0.562
9	0.562 TO 0.625
10	0.625 TO 0.688
11	0.688 TO 0.750
12	0.750 TO 0.812
13	0.812 TO 0.875
14	0.875 TO 0.938
15	0.938 TO 1.000

53-1723

F-5AB 3-1-141A

Figure 3-19. Deutsch Zip-Loc structural turnlock fastener data.

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Retaining ring. At first glance, the retaining rings used with Deutsch Zip-Loc fasteners look very similar to the retaining rings used with Milson fasteners. But, after a closer look, you should be able to distinguish between the two. The Deutsch fastener retaining ring has flat inside surface areas and is slightly open at its ends. The inside surfaces of the retaining ring used with the Milson fastener are curved, and the ends are butted together. Always make sure you are using the correct retaining ring for the type fastener you are installing.

Receptacle. The receptacle is fabricated from alloy steel, with an aluminum outer shell. Different styles of receptacles are available for various installation areas. The receptacle has a non-rotating threaded post on which the stud is threaded. This action causes the access panel or door to be tightly clamped against the substructure.

Retaining plate. The retaining plate, though not considered a basic part, is often used. It is riveted to the access door or panel to serve as a housing for the retaining ring. The inner surface is dimpled to form a recess for the retaining ring. The retaining plate is fabricated from corrosion resistant steel and usually comes predrilled.

Identification. Separate part numbers are used to identify the individual parts of the Deutsch Zip-Loc fastener. A typical part number for the stud is D1011-1-4. The D1011 is the basic stud part number, the -1, indicates the shank diameter (0.375), and the -4 denotes the grip length range (0.250 to 0.312). The specific -3 TO usually lists a breakdown of all the part numbers.

Exercises (640):

1. Just by looking at the heads of structural turnlock studs, how could you distinguish the Deutsch Zip-Loc stud from the Milson stud?

2. If you were given two different retaining rings, how would you be able to distinguish between the Deutsch Zip-Loc and the Milson retaining ring?

3. What physical feature of the Deutsch Zip-Loc stud would easily identify the Deutsch Zip-Loc stud from the Milson stud when only the bottom side of the studs are shown?

641. State the proper procedures to follow when installing a Deutsch Zip-Loc turnlock fastener.

Installation procedures. The installation procedures you use will depend on whether or not you use a retaining plate along with the other parts of the Deutsch Zip-Loc fastener. Since the installation procedures for the stud and receptacles are similar to those previously discussed for the Camloc and Milson fasteners, only the procedure for installing a retainer plate will be discussed here. Refer to figure 3-20, to aid in understanding the installation steps outlined below.

- Step 1. This step involves counterboring the substructure to provide a recess for the dimpled portion on the retaining plate. A low speed drill motor with a counterbore cutter having a pilot-guide slightly smaller than the stud hole, should be used. The substructure should be counterbored to a depth of 0.035 of an inch with a plus 0.005/-0.000 of an inch tolerance.
- Step 2. Once the substructure has been counterbored, drill the access door or panel for the retaining plate. Take a stud of the grip length required, insert it into the hole on the panel, and install the etaining ring. Position a retaining plate over the retaining ring. Place a spare receptacle over the retaining plate and then tighten the stud, fully clamping the receptacle and retaining plate against the material. With this accomplished, drill the predrilled holes in the retaining plate into the material.
- Step 3. With the stud still fastened, countersink the outer surface of the panel or door and the back side surface of the retaining plate. All holes should be countersunk to 100°.
- Step 4. Once the countersinking has been completed, separate the parts by removing the receptacle. Remove any burrs and drill shaving. Using Cleco fasteners, reposition the retaining plate over the stud, insuring that the rivet holes are aligned. Install the required rivets, producing a double-flush rivet installation. NOTE: If the stud has been removed, make sure a retaining ring is placed under the retaining plate, before riveting.
- Step 5. Step 5 will be needed only if for some reason you have removed the stud from the hole. If you have removed the stud, a special installation tool, called a loading rod, is needed. The loading rod is also required when it is necessary to replace studs after a new retaining ring has been installed in a riveted retaining plate.

Installation factors. When you are installing Deutsch Zip-Loc turnlock fasteners, the following must be foremost in your mind:

a. Studs installed on aerodynamic surface must meet the aerodynamic smoothness requirements of the area in which they are installed.

b. When the stud is to be installed in magnesium or titanium, apply one coat of epoxy primer to surfaces of stud which will contact the magnesium or titanium. Allow the primer to dry 30 minutes before installing the stud.

c. For installation holes, apply two coats of epoxy primer. Allow a minimum of 15 minutes drying

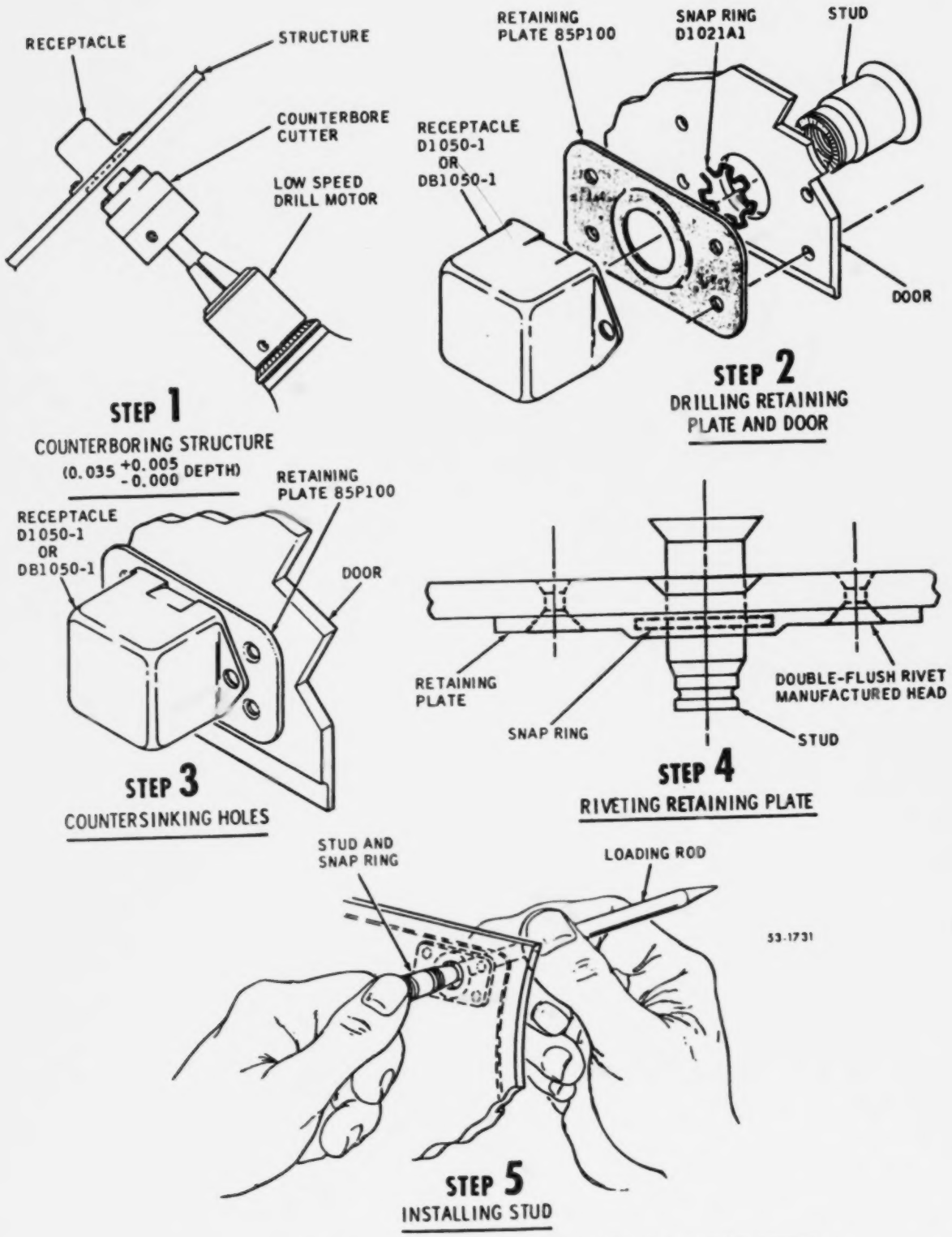
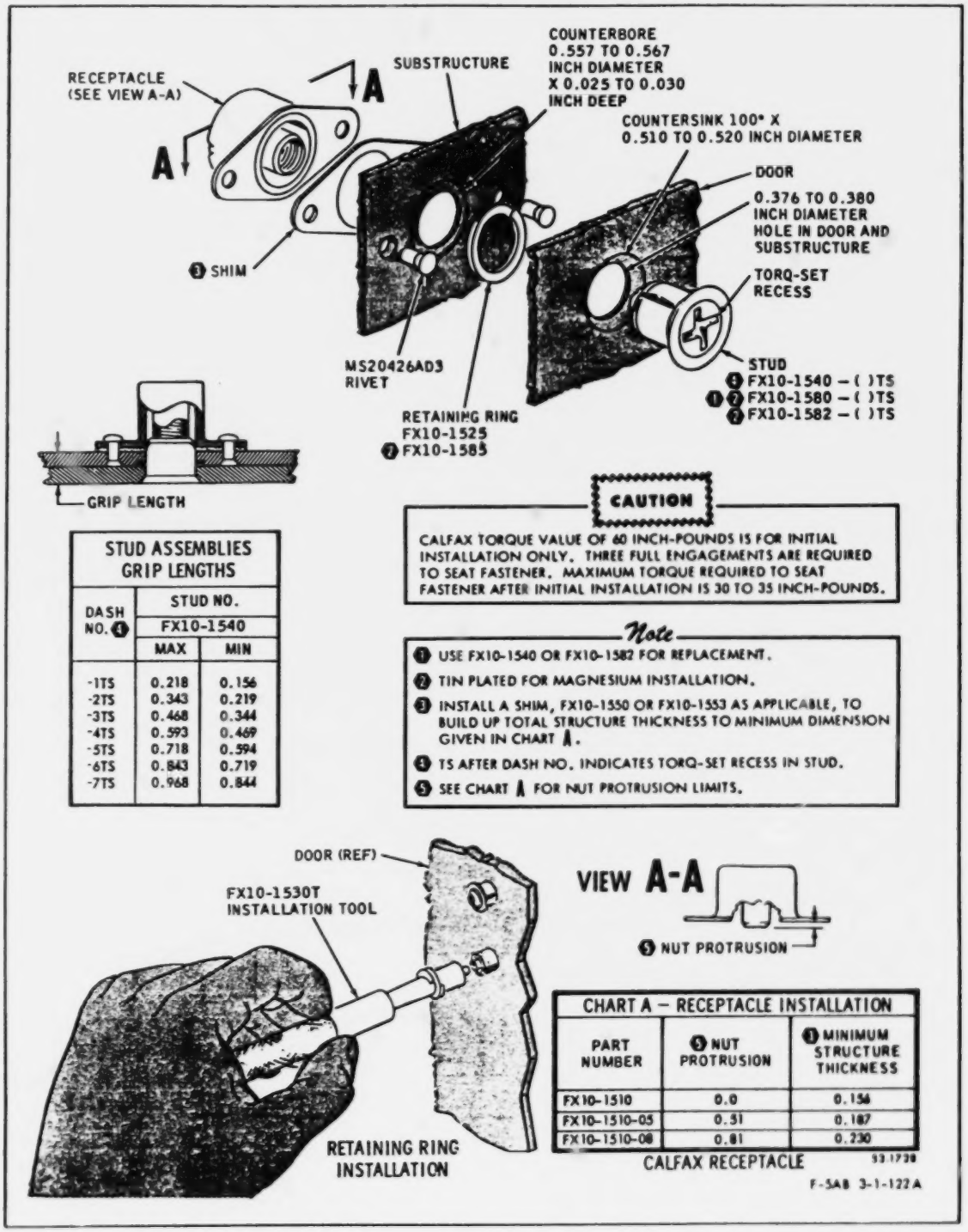


Figure 3-20. Deutsch Zip-Loc structural turnlock fastener retaining plate installation sequence.



STUD ASSEMBLIES GRIP LENGTHS		
DASH NO. 4	STUD NO. FX10-1540	
	MAX	MIN
-1TS	0.218	0.156
-2TS	0.343	0.219
-3TS	0.468	0.344
-4TS	0.593	0.469
-5TS	0.718	0.594
-6TS	0.843	0.719
-7TS	0.968	0.844

CHART A – RECEPTACLE INSTALLATION		
PART NUMBER	5 NUT PROTRUSION	1 MINIMUM STRUCTURE THICKNESS
FX10-1510	0.0	0.156
FX10-1510-05	0.31	0.187
FX10-1510-08	0.81	0.230

Figure 3-21. Calfax structural turnlock fastener data.

705

time between primer coats. An additional 30 minutes is required before installation of fasteners after application of the second coat of primer.

d. Installation torque is from 30 to 35 inch-pounds.

Exercises (641):

1. What tools would you select to form a recess for the substructure for the dimpled area of a retaining plate?

2. To find the correct locations for the rivets used in the retaining plate, what must you do?

3. At what point in the installation of the retaining plate, is the receptacle removed?

4. When is it necessary to use a loading rod during the installation of the retaining plate?

5. What must you do before installing Deutsch Zip-Loc studs when they are installed in magnesium structures?

642. Specify the working practices to employ when installing Calfox turnlock fasteners.

Calfax fasteners. The Calfax turnlock fastener, figure 3-21, like the previous structural turnlock fasteners, consists of three basic parts: a stud, a retaining ring, and a receptacle. All three parts are fabricated from alloy steel.

Stud. The stud is designed with a torque-set recess in the head of the shank. Also, it has a threaded post inside the shank of the stud. This post is threaded into the nut assembly inside the receptacle. One side of the shank has a press-type wire clip that holds the head of the stud against the panel when the fastener is unlocked. A retaining ring groove is also incorporated on the bottom section of the stud.

Retaining ring. Retaining rings are available in two types — flat and dimpled. The flat-type is a spiral ring design used when the substructure is counterbored. The dimpled type, which looks like a dimpled washer, is used when the holes for the stud in the access panel or door are dimpled.

Receptacle. Receptacles are available in various styles for different areas of installation. A nonrotating nut assembly is contained within the receptacle. The action of the threaded post within the stud being threaded into this nut assembly results in the panel being clamped tightly against the substructure. A shim of 5052 aluminum alloy is sometimes used under the receptacle when it is necessary to increase the total structure thicknesses to meet minimum structure thickness, (see Chart A of figure 3-21).

Installation factors. As with each type of structural turnlock fasteners, you must remember specific factors related to the type of fastener being installed. Factors related to the Calfax turnlock fastener are as follows:

a. Holes drilled, countersunk or counterbored, for the stud and receptacles must produce a close mating fit between structural parts for maximum strength.

b. Studs installed on aerodynamically smooth surfaces must meet the aerodynamic smoothness requirements for the area in which they are installed.

c. When installing Calfax fasteners in magnesium structures, use a tin plate stud assembly and retaining ring. Also use epoxy primer as stated for Deutsch type turnlock fasteners.

d. An initial torque value of 60-inch-pounds is required for Calfax fasteners. Three full thread engagements are required to seat the fasteners. Maximum torque required to seat the fastener after initial installation is 30 to 35 inch-pounds.

Exercises (642):

1. If you were installing Calfax fastener studs in dimpled holes, what type of retaining rings should you use?

2. What is sometimes used to meet minimum structure thickness requirements when installing Calfax fasteners?

3. When tightening a Calfax fastener stud, what is the torque requirements needed to fully seat the stud after the access panel has been removed and replaced several times?

CHAPTER 4

Common and Special Hardware

IN THIS CHAPTER, the discussion will center around the identification, characteristics, and installation procedures necessary for correct usage of common fasteners. The word "common" refers to fasteners—such as bolts, screws, washers, and nuts—which are found on all types of aircraft. The discussion will give the do's and don'ts necessary to eliminate unsafe conditions. Further, the discussion will briefly look at special types of hardware, primarily hinge assembly and quick release type latches. You will need this information contained in this chapter so that you may correctly identify and requisition these fasteners and correctly operate the equipment involved.

4-1. Types of Common Hardware

In the fabrication of aircraft, where rivets and turnlock fasteners are unsuitable or impractical, bolts, screws, washers, and nuts are used to assure a sound structure.

Bolts are used where great strength is required to join parts which are under high tension of shear—parts on which great pulling forces are exerted. Consequently, the materials from which these bolts are manufactured must be as strong as other materials used in the aircraft. Screws are the most common fasteners used in aircraft. They are similar to other types of fasteners, such as bolts, but differ mainly by usually having a lower material strength, a loose thread fit, and shanks threaded along the entire length. Aircraft nuts are made in many shapes and sizes and of different materials; they are available in either right- or left-hand-threads. Nuts do not come with the bolts when bolts are ordered. Both must be ordered separately.

You have studied some of the various fastening devices used to fasten materials together. Some of these fastening devices allow quick dismantling or replacement of aircraft parts that must be taken apart and put back together at frequent intervals. Riveting or welding these parts each time they are serviced soon weakens or ruins the joint. Furthermore, some joints require greater tensile strength and stiffness than rivets can give. Bolts are one type of fastening device which give the required security and rigidity. Bolts are generally used where great strength is required, and screws where strength is not the deciding factor.

643. Distinguish between true and false statements concerning the construction, use, and marking of aircraft bolts.

Aircraft Bolts. Bolts and screws are similar in many ways. Both are pins or rods made of aluminum alloy or steel. They are used for fastening or holding, and each has a head on one end and screw threads on the other. Regardless of these similarities, there are several distinct differences between the two types of fasteners.

The threaded end of a bolt is always blunt; that of a screw may be either blunt or pointed. The threaded end of a bolt must have a nut screwed onto it to complete the assembly. The threaded end of a screw may fit into a female receptacle or it may fit directly into the metal being secured. A bolt has a fairly short-threaded section and a comparatively long grip length or unthreaded portion. The screw has a longer threaded section and no clearly defined grip length. A bolt assembly is generally tightened by turning the nut on the bolt; the head of the bolt may or may not be designed for turning. A screw is always tightened by turning its head.

When it becomes necessary to replace aircraft fasteners, use duplicate fasteners if at all possible. If duplicate fasteners are unavailable, use exteme care and caution when making fastener substitution. When fastener substitution is necessary, obtain the services of a competent aeronautical engineer to assit you in making the proper selection or refer to the substitution charts in the applicable technical order.

Dimensional features. Aircraft bolts are fabricated from cadmium or zinc-plated corrosion-resisting steel, unplated corrosion-resistant steel, and anodized aluminum alloy. The configuration of a bolt will depend on such factors as grip length, bolt length, thread length, and diameter. Figure 4-1, illustrates the relationship of these terms to a bolt.

a. Grip length. (Letter G - fig. 4-1). The distance from the underhead bearing surface to the start of the thread is called the grip length. Accordinly, the thickness of material held together by the bolt is called the grip. The ideal installation would have a bolt whose grip length would be a few thousands of an inch shorter than the actual material thickness to avoid bottoming the nut.

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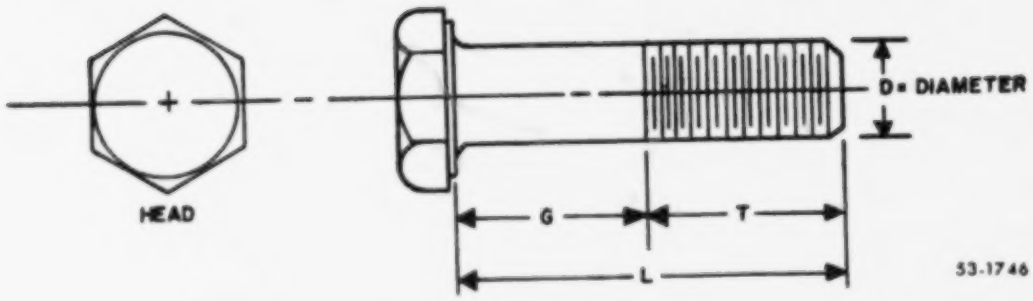


Figure 4-1. Bolt configuration.

b. Bolt length. (Letter L - fig. 4-1). The bolt length is the overall length of the bolt, including the grip length portion and the threaded portion. All bolt installations which involve self-locking or plain nuts will have at least two complete threads protruding through the nut. These two threads include the chamfered end of the bolt. However, bolts of slightly greater grip length than that required may be used if washers are placed under the nut or bolt head; or if plate nuts are used, shims are added under the plate.

Although there is no maximum for the number of threads over the minimum of two, they should be kept to a practical minimum in the interest of weight and professional appearance. The pressure required to strip a nut off a threaded bolt should be larger than the tensile strength of the bolt it is used on.

c. Thread length. (Letter T - fig. 4-1). Bolts are equipped with inclined threads for the purpose of rotating on a nut which has like threads. There are two general types of threads in use in the United States at this time: National Fine (NF) and National Coarse (NC). (For tables describing NF and NC threads, see TO 1-1A-8.) Both type threads are designed as the number of times the incline (threads) rotate around a given diameter bolt or screw in a 1-inch length of that diameter bolt or screw. For example, a 428 thread indicates that a 1/4 inch diameter bolt has 28 threads in 1 inch of its length.

Threads are also designated by class of fit. By class of fit, we mean how hard the nut turns on the thread. The higher number the fit, the more difficult it is to install the nut. For example, a class 1 fit is a loose fit and can easily be turned on with the fingers. A class 3 fit will require a wrench to turn the nut.

d. Diameter. (Letter D - fig. 4-1). The diameter of a bolt refers to the shank diameter of the bolt. When installing bolts, you must know the correct nominal diameter to obtain proper fit requirements. You will need a micrometer to segregate bolts into their nominal diameter sizes.

Identification of bolts. Bolts are manufactured in many shapes and varieties. They may be classified by the shape of head, method of securing, and usage. The head shape may be hexagon, square, eye, or internal wrenching. They are identified by either bolthead markings or part number designations.

a. Bolthead markings. Bolts are designed and fabricated of different materials and with different tensile strengths for their individual heat ranges and grip stresses. Each bolt is marked with a code for identification and physical characteristics. Figure 4-2 illustrates just a few of the head markings.

b. Part number designation. AN (Army-Navy), NAS (National Aircraft Standards), MS (Military Standards), and AMS (Aerospace Materiel Specifications) are standards and specifications set up by Government agencies and civilian organizations to govern the manufacturer of aerospace materials. The AN and MS Standards are military Standards and are in general use by the respective Government agencies. Many of the AN Standards have been converted to and replaced by MS Standards.

The bolt part number designation gives the type of bolt, diameter, length, and length of grip; it also

Figure 4-2. Bolt head markings.

states if the head or shank is drilled. An example of a designation is NAS1104-10D. NAS1104 signifies that the bolt is a National Aircraft Standard designed bolt (hex head); the number 4 in the NAS number indicates a 1/4 of an inch diameter; -10 indicates the grip length (.625), and D denotes that the shank is drilled. If the head were drilled, a letter H would be used. You should consult TO 1-1A-8 for tables of the various types of bolts and an explanation of the code numbers used to identify the individual bolts.

Exercises (643):
Identify the true and false statements related to aircraft bolts by placing the letter T or F in the space provided in front of each statement.

_____ 1. The threaded end of a bolt is always blunt.
_____ 2. A bolt has no clearly defined grip length.
_____ 3. A bolt is always tightened by turning the head.
_____ 4. A bolt is ideally installed when the grip length is a few thousands of an inch shorter than the material thickness.
_____ 5. All bolt installations must have at least two complete threads protruding through the nut.
_____ 6. The maximum amount of thread protrusion through the nut is limited to four threads.
_____ 7. The grip length of a bolt refers to the threaded portion of the shank.
_____ 8. A close tolerance aluminum alloy bolt has a head marking of two raised dashes.
_____ 9. The letter D in a bolt part number indicates that the shank is drilled.
_____ 10. Bolt threads which require the use of a wrench to turn the nut, are classified as a class 1 fit.

644. Identify the types of aircraft bolts.

Types of aircraft bolts. Most bolts used in aircraft structure are either general purpose, internal wrenching, or close-tolerance AN (Air Force-Navy), NAS (National Aircraft Standard), or MS (Military Standard) bolts. In certain cases, aircraft manufacturers are compelled to make bolts of different dimensions or greater strength than the standard type. Such bolts are made for a particular application and it is extremely important to use like bolts in replacement. If such bolts are not available and must be fabricated locally, the identical material and heat treatment specified in the applicable drawings or an authorized substitute material with its proper heat treatment should be used. Such special bolts are usually identified by the letter S stamped on the head.

a. General Purpose. The AN3 through AN20 aircraft bolts are all-purpose structural bolts used for general applications involving tension or shear loads. These bolts are of either cadmium- or zinc-plated, noncorrosion-resistant steel, or anodized aluminum alloy. The bolts conform to Military Specifications MIL-B-6812, with rolled threads, NF-3 fit, conforming to Military Specification MIL-S-7742.

This type of aircraft bolt is not machined as carefully as a close tolerance bolt. General purpose bolts are hex-headed and are used in repair work or for attachment of assemblies where a light drive fit is permissible (.006-inch clearance for a 5/8-inch hole, and other sizes in proportion). The head may or may not be drilled for safetying, and the threaded section of the shank may or may not be drilled for cotter pin securing.

b. Internal wrenching bolts (fig. 4-3). These bolts are fabricated from high-strength steel and are used where severe tension occurs. When they are used in steel parts, the bolt hole must be slightly countersunk to seat the large corner radius of the shank at the head. In dural material a special heat-treated washer must be used to provide an adequate bearing surface for the head. The head of the internal wrenching bolt is recessed to allow the insertion of an internal wrench when you are installing or removing the bolt. Standard AN hex head bolts cannot be substituted for these bolts, as these are heat-treated to 160,000 to 180,000 psi. Special nuts must also be used on these bolts.

c. Close tolerance bolts (fig. 4-4). These close-tolerance bolts are used in applications where the bolted joint is subject to severe load reversals and vibration. The shanks of these bolts have a close tolerance, permitting a very close fit with the use of reamers. The standard AN hex head bolts are otherwise identical, and may be used for the same applications as the steel close-tolerance bolts, provided a light-drive fit is obtained. The use of a close-tolerance bolt permits elimination of lost motion in landing gears, control systems, etc.

They are available in two head types, the standard hex head and 100° countersunk head. The countersunk head has one of the following recesses: the cross, the slotted, the hexagonal wrench type or a Torq-set.

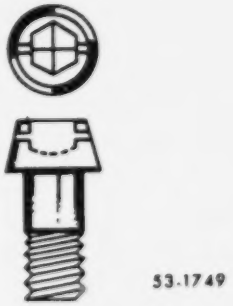


Figure 4-3. Internal wrenching bolts.

709

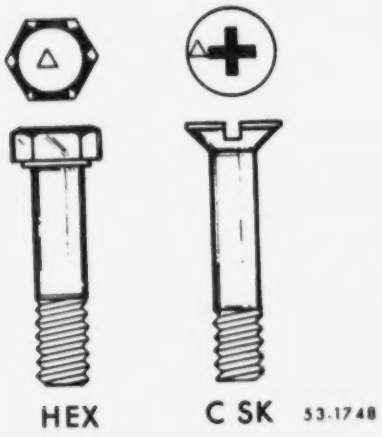


Figure 4-4. Close tolerance bolts.

The Torq-set wrenching recess, figure 4-5, incorporates four driving wings, which are radial to the vertical axis of the bolt, rather than tangent with respect to the axis. Also, there is no taper in the walls of the recess. This recess permits higher installation and removal torques with no tendency for the driver to slip or cam out.

CAUTION: Caution must be exercised in the use of close tolerance bolts for all critical applications. You must refer to the specific aircraft maintenance technical order for specific instructions for use of these bolts.

Hi-Torque bolts. The Hi-Torque bolts (Hi-Shear Rivet Tool Company) have not had a military designation assigned to them. These bolts use a variety of steel alloys and titanium. The recess is a single slot, narrower at the center than the outer portions at either end. This, and the center dimple, make the recess readily identifiable by its "bow tie" appearance. The recess is undercut in a taper from the center of the recess to the outer boundaries, producing an inverted keystone shape in cross-section.

A solid head driver conforming to MS33750 shall be used for installation. The driver number will identify the proper driver size for standard 100° head bolts (HTS-5 driver; 5/16 diameter bolt). In addition, the proper driver for a particular bolt has approximately the same tip diameter as that of the bolt head. This is applicable to the standard 100° flush head as well as the reduced 100° flush head. However, the reduced head has a recess one size smaller than the standard and requires the next size smaller driver. The dimple provides for self-engagement of the driver into the recess, and as torque is applied the driver tip locks into the recess walls eliminating the need for end thrust by the operator. Figure 4-6, illustrates the drivers required.

Self-locking bolts. These bolts are manufactured to regular standards such as MS20004 through MS20024, NAS 333 through NAS340 and NAS 1303 through NAS 1320 except that they incorporate a nylon pellet or strip forced into a hole or slot in the body of the threads. (See fig. 4-7.) The nylon pellet or strip is compressed when the bolt is wrenched into a tapped hole. As a result of the nylon's resilient "memory," the pellet or strip constantly fights to return to its original shape. This action creates a pressure which locks the bolt. Used self-locking bolts will be suitable for reuse provided the bolt is in a serviceable condition and the nylon pellet is not loose or broken and extends at least to the outermost edge or apex of the threads and insures sufficient friction for locking capability. These types of self-locking bolts are necessarily restricted to temperature applications not in excess of 250° F.

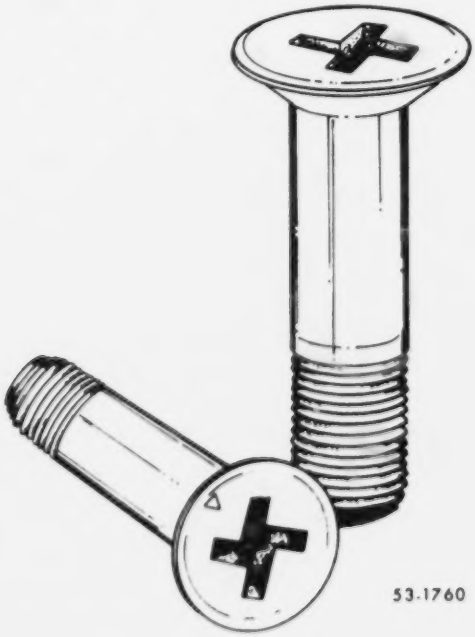
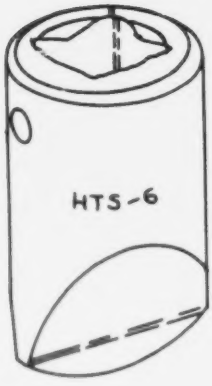


Figure 4-5. Torq-set recess.

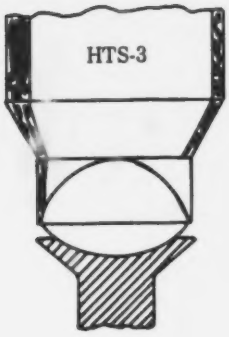
Exercises (644):

In the space provided at the end of each statement, write in the type of bolt that matches the statement.

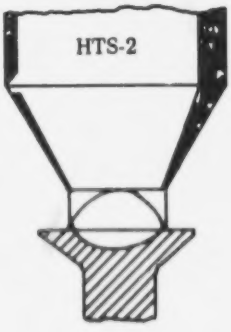
1. The type of bolt is used where the bolted joint is subjected to severe load reversals. _____
2. This type of bolt requires that the hole be slightly countersunk to seat the large corner radius of the shank at the head. _____
3. The type of bolt is used for general application involving tension or shear loads. _____
4. This type of bolt has a definite temperature limitation. _____
5. This type of bolt requires the use of a special heat-treated washer. _____
6. This type of bolt has a head marking which indicates the size of the installation tool required. _____
7. This type of bolt is available with a Torq-set recess. _____

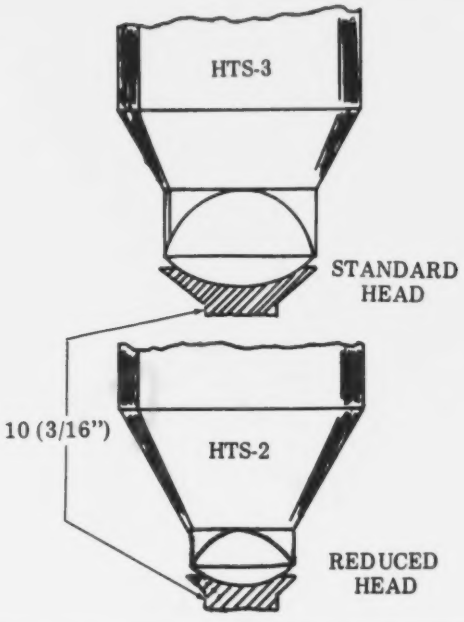


Too small a driver does not fit the recess arc which results in damage to recess, even at low torque values.



The correct driver makes a snug fit with the arc of the recess.





Driver Selection Chart STANDARD HEAD			
NOM. BOLT DIA.	DRIVER NO.	NOM. BOLT DIA.	DRIVER NO.
#8	**HTS-2	7/8	HTS-14
#10 (3/16)	**HTS-3	1	HTS-16
1/4	HTS-4	1-1/8	HTS-18
5/16	HTS-5	1-1/4	HTS-20
3/8	HTS-6	1-3/8	HTS-22
7/16	HTS-7	1-1/2	HTS-24
1/2	HTS-8	1-5/8	HTS-26
9/16	HTS-9	1-3/4	HTS-28
5/8	HTS-10	1-7/8	HTS-30
3/4	HTS-12	2	HTS-32

**The tip thickness of the HTS-2 and HTS-3 are the same but they do not have the same radius and are therefore not interchangeable.

53-1962

Figure 4-6. Hi-Torque drivers.

645. In given instances involving installing aircraft bolts, cite the proper work procedure to use.

Installing aircraft bolts. Just as the size of the hole for rivet installation is important, so is the size of the hole important for bolt installation. All holes drilled for bolts should produce a good mechanical fit because, unlike rivets, bolts cannot be swage to fill up the hole.

a. Bolt and hole sizes. Slight clearances in bolt holes are permissible wherever bolts are used in tension and are not subject to reversal of load. A few of the applications where clearance of holes is permitted include pulley brackets, conduit boxes, lining trim, and miscellaneous supports and brackets. A slight clearance fit is defined as an interference fit if it is 0.006 of an inch for 5/8 inch diameter bolts or a proportionate amoung of interference for other size bolts. Interference fits are required in places where bolts are used in repair or where they are placed in the original structure.

The fit of holes and bolts cannot be defined in terms of shaft and hole diameters; fit is defined in terms of the friction between bolt and hole when the bolt is driven into place. (See table 4-1.) A tight drive fit, for example, is one in which a sharp blow of a 12- or 14-ounce hammer is required to move the bolt. A bolt that requires a hard blow and sounds tight is con-

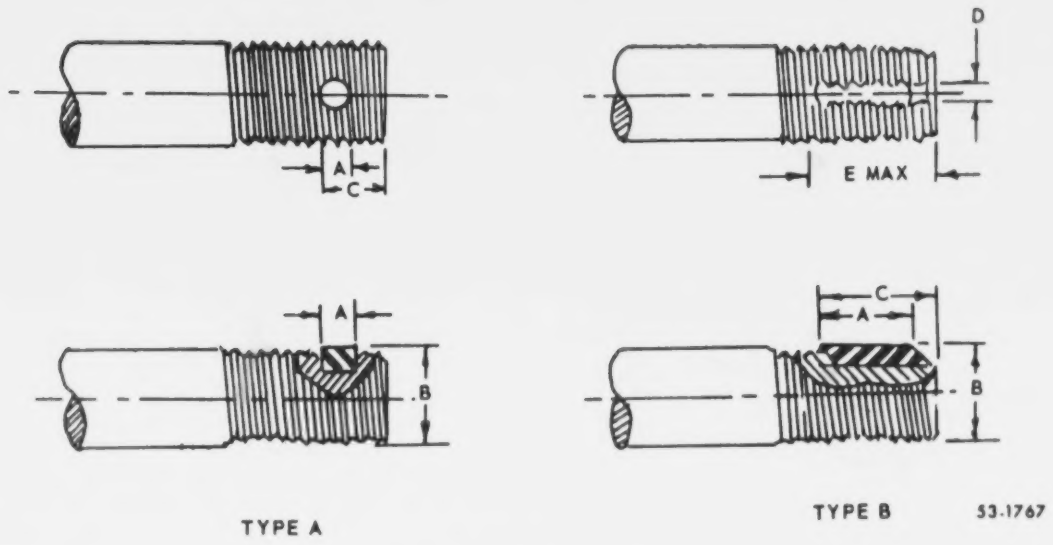


Figure 4-7. Self-locking bolts.

sidered to fit too tight. A lightdrive fit is one in which a bolt will move when you hold a hammer handle against its head and press by the weight of your body. A bolt which moves when pushed with your thumb is considered too loose.

To obtain a light-drive fit, measure several bolts of the correct nominal size with a micrometer; then separate them into three groups, large, medium and small. (From the earlier discussion of the rivet sizes, remember that the nominal size is the quoted size. A 1/4-inch or .250 bolt, for example, may measure only .249-inch instead of .250 inch. The nominal size then would be .250 inch and the actual size .249 inch.) Drill an initial hole approximately 1/32 inch undersize (1/8 inch undersize may be used for larger bolts) and then redrill to 1/64 undersize.

Select a reamer which can cut a hole that will give proper drag when using the smallest bolts. Ream two or three holes and fit the small bolts in the reamed holes. If the hole is too small, make it larger by selecting another reamer of the same nominal size but which will cut a hole slightly larger. If any of these holes is too large for light-drive fit conditions with the small bolts, then the medium or large bolts will probably be just right for a light-drive fit. Drill sizes for bolts are listed in figure 4-8 and may be used when drilling holes for AN bolts.

Bolt holes must not be oversized or elongated. A bolt in such a hole will carry none of its shear load until parts have yielded or deformed enough to allow the bearing surface of the oversized hole to come in contact with the bolt, as shown in figure 4-9. In this respect, remember that bolts do not become swaged to fill up the holes as do rivets. Therefore, for oversized or elongated holes, it is permissible to drill or ream the hole to accommodate the next larger bolt, provided

TABLE 4-1
CLASSIFICATION OF BOLT FIT

FIT	TOLERANCE	USE
Press	See Use	This Fit is usually referred to as so many thousandths of an inch tight, indicating that the bolt or pin is that much larger than the hole. Normally used on machine assemblies and assembled with the aid of an arbor press or temperature shrinkage.
Class I	±0.001"	Used when one or two bolts are provided in a critical joint, subject to reversal of loads. Holes are reamed on assembly.
Class II	±0.002"	Used where there are more than two bolts through primary structure, where vibration and reversal of loads are present, or when rigidity is desired. Holes are reamed on assembly.
Class III	±0.005 to ±0.010"	Tolerance depends on the size of bolt. Used where there is a large number of bolts not subject to reversing, such as Access Doors, Fairings, etc.

53-1765

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BOLT DIAMETER	PILOT HOLE DRILL SIZE	FINAL DRILL OR REAM SIZE
3/16 (10-32)	No. 21 (.159)	No. 11 (.191)
1/4	7/32 (.2187)	1/4 (.250)
5/16	9/32 (.2812)	5/16 (.3125)
3/8	11/32 (.3437)	3/8 (.375)
7/16	13/32 (.4062)	7/16 (.4375)
1/2	15/32 (.4687)	1/2 (.500)
9/16	17/32 (.531)	9/16 (.5625)
5/8	19/32 (.594)	5/8 (.625)
3/4	23/32 (.719)	3/4 (.750)
7/8	27/32 (.844)	7/8 (.875)
1	31/32 (.969)	1 (1.000)

53-1778

Figure 4-8. Bolt hole sizes.

the larger hole size does not weaken the part. Consult a qualified engineering officer before resorting to drilling or reaming. All bolt holes must be perpendicular to the surface involved to provide full bearing surface for the bolt head and nut.

b. Torque. To avoid stripping threads, cracking nuts, or snapping bolts, and to assure that all bolts carry their share of the load, torque all nuts. This means that for every nut you install, you measure the tightening of twisting force or, after much experience, estimate it accurately so that the twisting force will be correct.

Torque is the product of the applied force and the distance it is applied from the center of the nut. This value may be expressed in pound-inches or in pound-feet; the force is measured in pounds, and the distance from the center of the nut is measured in inches or feet. Thus, a force of 40 pounds applied at the end of a wrench 12 inches long will develop a twisting force of 480 pound-inches. If 40 pounds of force were applied at the end of a 3-foot bar and wrench, a twisting force of 120 pound-feet would be developed. (This value could also be given as 1440 pound-inches).

Nuts which are tightened without a torque wrench are seldom drawn up to the correct tightness. They are either overtightened because of the variable involved, or they are under torqued because of unsuspected friction. Such guesswork may result in aircraft failure. Tables for the torquing of bolts have not been set up for aircraft use, but tables to be used when torquing nuts have been established. Use these torque tables in applying nuts. Follow the directions in the maintenance instruction manuals for specific aircraft.

c. Installation factors. The following are some of the installation factors to keep in mind when you install aircraft bolts.

- Steel bolts smaller than 10/32 of an inch and aluminum alloy bolts smaller than 1/4 of an inch diameter are easily overstressed; therefore, they are not to be used in primary structure of the aircraft.
- To prevent corrosion caused by contacting surfaces of dissimilar metal, use aluminum alloy washer (AN960) with steel bolts on aluminum alloy parts and steel washers on steel parts.
- In cases where high torque must be applied to the bolts, use steel washers regardless of whether the part is steel or aluminum alloy.
- Do not install cadmium plate bolts in areas with operating temperatures in excess of 450° F. because the bolts are subject to cadmium embrittlement and subsequent failure under these conditions.
- Use gang channel or floating plate nuts with bolts in frequently removed doors, panels, or parts to prevent binding of fasteners due to misalignment of mating holes and to insure interchangeability of parts.
- Clear all foreign material from recesses in the heads of bolts, especially the Hi-Torque Torq-set, before installation or removal.
- If a bolt has been tested for hardness on the shank, discard it. Hardness testing usually involves removing the plating which may lead to corrosion.

Exercises (645):

1. What installation tool is required for installing bolts in a tight drive fit hole?

2. If you are installing bolts having a nominal diameter size of 1/4 inch, what size hole is required prior to reaming?

3. If bolt holes are oversized or elongated and require reaming, what action would you take first?

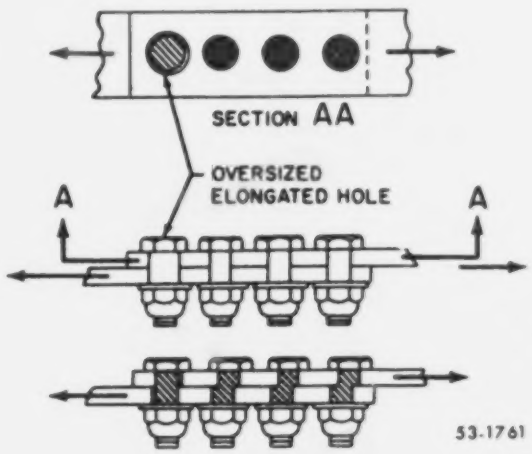


Figure 4-9. Bolt hole misalignment results.

4. If you were making repairs in the primary structure of the aircraft, what would be the smallest aluminum aloy bolt you could use?

5. If you were installing steel bolts in aluminum structure requiring a high torque, what type washer would you use?

646. Given characteristics of aircraft screws, identify the classification of the screw described.

Aircraft Screws. Screws are among the most commonly used threaded fastening devices on aircraft. They are generally made of lower strength materials than are used for bolts. They can be installed with a loose-fitting thread, and the head shapes are made to engage a screwdriver or wrench. Some screws have no clearly defined grip or unthreaded portion whereas others are threaded along their entire length. The coding system used to identify screws is similar to the one used for bolts. There are AN and NAS screws. NAS screws are structural screws. Part numbers 510, 515, 550, and so on, catalog screws into classes, such as roundhead, flathead, washer head, and so on. Letters and digits indicate the material composition, length, and thickness. Figure 4-10 explains the coding system used to identify screws.

AN500—6—7
AN = AIR FORCE - NAVY STANDARD
500 = FILLISTER-HEAD SCREW, COARSE THREAD
6 = DIAMETER SIZE — NUMBER 6
7 = LENGTH IN 16THS OF AN INCH
AN501B—416—7
AN = AIR FORCE - NAVY STANDARD
501 = FILLISTER-HEAD, FINE THREAD
B = BRASS
416 = 4/16-INCH DIAMETER
7 = 7/16-INCH LENGTH
THE LETTER 'D' IN PLACE OF THE 'B' WOULD INDICATE THAT THE MATERIAL IS 2017T ALUMINUM ALLOY. THE LETTER 'C' WOULD DESIGNATE CORROSION RESISTING STEEL.
AN 'A' PLACED BEFORE THE MATERIAL CODE LETTER WOULD INDICATE THAT THE HEAD IS DRILLED FOR SAFETYING.
NOW LET US EXAMINE A CODE NUMBER FOR AN 'NAS' SCREW.
NAS228DD—8
NAS = NATIONAL AIRCRAFT STANDARD
228 = HEAD STYLE AND RECESS — BRAZIER HEAD RECESSED FOR A 'REED AND PRINCE' SCREWDRIVER.
DD = 2024T ALUMINUM ALLOY — ABSENCE OF A LETTER INDICATES ALLOY STEEL
8 = SCREW LENGTH IN 16THS OF AN INCH
53.1777

Figure 4-10. Screw numbering system.

Classification. Screws are classified in three groups: (1) structural screws, which have the same strength as equal size bolts; (2) machine screws, which include the majority of types used for general repair; and (3) self-tapping screws, which are used for attaching lighter parts.

a. Structural screws. Structural screws are made of alloy steel, are properly heat treated, and can also be used as structural bolts. These screws are manufactured in the NAS 220 through NAS227, AN509, and AN525 series. They have a definite grip and the same shear strength as a bolt the same size, as shown in figure 4-11. Shank tolerances are similar to AN hex head bolts, and the threads are National Fine. Structural screws are available with round, brazier, or countersunk heads. Use either a Phillips or a Reed and Prince screwdriver to install recessed head screws.

The AN509 (100°) flathead screw is used in countersunk holes where a flush surface is necessary. The AN525 washer-head structural screw is used where raised heads are not objectionable. The washerhead screw provides a large contact area. Several types of structural screws differ from the standard structural bolts only in head style. The material in them is the same, and a definite grip length is provided. The AN 525 washer head screw and the NAS220 through NAS227 series are such screws.

b. Machine screws. Machine screws are available in a variety of head styles, as shown in figure 4-12. These screws are general purpose screws and are available in low-carbon steel, brass, corrosion-resistant steel, and aluminum alloy. They should not be used to replace structural screws.

Roundhead screws AN515 and AN520 have either slotted or recessed heads. The AN515 screw has coarse threads, and the AN520 has fine threads. Countersunk machine screws are listed as AN505 and AN510 for 82°, and AN507 for 100°. The AN505 and AN510 correspond to the AN515 and AN520 roundhead in material and usage. The filister-head screw, AN500 through AN503, is a general-purpose screw and is used as a capscrew in light mechanisms. This could include attachments of cast aluminum parts, such as gearbox cover plates.

The AN500 and AN501 are available in low-carbon steel, corrosion-resistant steel, and brass. The AN500 has coarse threads; the AN501 has fine threads. These screws have no clearly defined grip length. The screws that are larger than number 6 have a hole drilled through the head for safetying purposes. The AN502 and AN503 filister-head screws are made of heat-treated alloy steel, have a small grip, and are available in fine and coarse threads. These screws are used as capscrews where great strength is required. The coarse-threaded screws are commonly used as cap screws in tapped aluminum alloy and magnesium castings because of the softness of the metal.

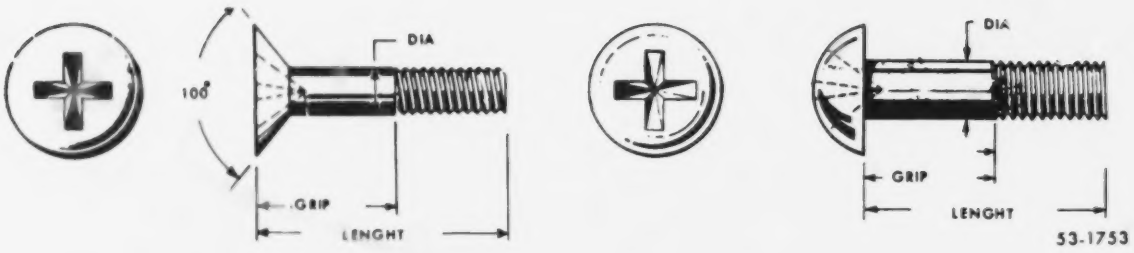


Figure 4-11. Structural screws.

c. Self-tapping screws. Machine self-tapping screws are listed as AN504 and AN506. The AN504 screw is roundhead, and the AN506 is 82° countersunk. These screws are used for attaching removable parts, such as nameplates, to castings and parts in which the screw cuts its own threads after the part has been underdrilled.

NOTE: Self-tapping screws should not be used to replace standard screws, nuts, bolts, or rivets in the original structure.

Installation factors. The most common problem encountered when installing aircraft screws is cross-threading. Always turn the screw by hand to insure that the threads are matched before applying torque. The use of pneumatic installation tools should be avoided because of possibilities of stripping out the screw threads or rounding out head recesses. Also, damage to plate nuts, especially gang channel nut assemblies, usually results from excess torque. To prevent damage to the screw and surrounding structures, always use the proper screwdriver.

Exercises (646):

Identify the screw classification described in each statement by writing in the class of screw in the place provided at the end of each statement.

1. Screws with a definite grip length. _____
2. Screw used to attach nonstructural parts to castings. _____
3. These screws are used as capscrews where strength is required. _____
4. Same shear strength as bolt the same size. _____
5. Use for general repairs. _____
6. Manufactured in the NAS 220 through NAS 227 series. _____
7. Shank tolerances are similar to AN hex head bolts. _____

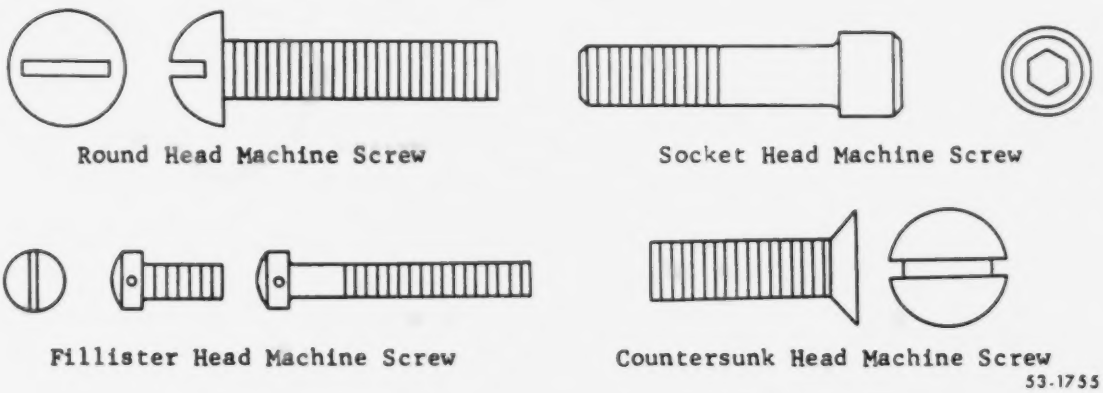


Figure 4-12. Machine screws.

8. Threaded along the entire shank length. _____

9. Used in underdrilled holes. _____

10. The AN 504 screw is used in countersunk hole. _____

647. State important factors concerned with the use of aircraft nuts.

Aircraft Nuts. Very often the importance of the nut to the total strength requirements of a bolted or screwed assembly is overlooked. Just by using a self-locking nut does not insure that you have selected the correct nut. A self-locking design is just one of many factors you must consider. To understand the importance of a nut, you need a closer look at its purpose and the factors affecting its use.

Purpose. The purpose of any nut is to properly load the bolted assembly. To do this there must be a mating condition of the threads. Although the thread form of a nut is accurate, it cannot be made identical to that of the bolt. The nut must be plastic enough to allow the threads to slightly deform upon tightening and adjust to distribute the load over all threads rather than just the first few. A tough non-heat-treated nut can do this whereas a heat-treated nut cannot since it will not conform to the bolt threads. Hardened nuts can actually damage the bolt threads to which they are applied, resulting in low tension and loss of holding power vital to fastener performance. A nut should be no harder than is necessary to fully load the fastener assembly.

Installation factors. Loose assemblies often spell disaster to both man and equipment. Neglecting to apply or maintain enough of a preload leaves fasteners wide open to early fatigue. Using a strong bolt is not enough. Only when you tighten the bolt beyond the working load do you get a factor of safety. The greater the clamping force (preload) developed, the less will be the tendency of parts to creep or shift; also the possibility of a nut backing off or loosening in service is greatly reduced.

Therefore, to increase performance of the fastener assembly you must observe one simple rule: tighten assemblies beyond their working loads and keep them tight, for if the preload applied is greater than the service load encountered there can be no fatigue failure.

Fatigue failure. Fatigue failure accounts for over 75 percent of all fastener problems. Fatigue breaks are caused by insufficient tightening and lack of proper preload or clamping force. This results (1) in movement between the parts of the assembly in use, and (2) in bending back-and-forth or cyclic stressing of the screw. Eventually a tiny crack forms at the high stress points; and as the vibration, movement, and bending are continued, a second crack, then a third, fourth, and so on, are formed. These tiny cracks, occurring progressively as the bending takes place, cause the part to become weaker until it can no longer support the load. At this point the screw or bolt breaks in tension or pulls apart.

Torque. The correct torque to apply when tightening an assembly is a difficult decision because there are so many variables. The screw or bolt takes two stresses when it is tightened: (1) torsion and (2) tension. Tension is the desired stress. Torsion is the necessary evil due to friction. A large percentage of applied torque goes to overcome friction, yet only tension remains after tightening. About 50 percent of the torque is absorbed in overcoming friction on the working faces of the bolt and nut; then 40 percent is taken up by thread friction, leaving only 10 percent to apply bolt tension (preload).

Standard torque charts have been established for average dry unplated conditions; but surface variations such as thread roughness, scale, paint, lubrication, (oil, grease, etc.) hardening, and plating may alter these values considerably. Also nuts that are reused will require higher torque reading. Torque values will also vary with manufacturers.

To obtain the correct recommended torque value on a self-locking nut, run the nut down until it is one turn from the beginning of seating. At this point, note the prevailing torque. If the prevailing torque is less than one-third of the recommended torque, disregard it and tighten the nut to the recommended torque value. If the prevailing torque is one-third or more than one-third of the recommended torque, add it to the recommended torque. Example: The recommended torque is 50 to 70 inch-pounds. The prevailing torque at one turn from the beginning of seating is 30 inch-pounds. The correct torque wrench reading would be 80 to 100 inch-pounds.

Exercises (647):

1. What is the purpose of a nut in a bolted assembly?

2. When tightening a bolted joint, what must you do to obtain a safety factor in the bolted assembly?

3. How can you increase the performance of a bolted assembly?

4. What causes fatigue failure in bolted assemblies?

5. What two forces are encountered when tighening a bolted assembly?

6. What percentage of the torque required when tightening bolts, preloads the bolted assembly?

7. Why is a tough non-heat-treated nut preferred over a heat-treated nut?

648. Point out requirements concerning the amount of thread protrusion and the various finishes associated with aircraft nuts.

Thread protrusion. In all installations, bolts or screws will protrude no less than two complete threads past the nut. This applies to both self-locking and plain nuts, and includes any chamfer at the bolt end. The requirement for thread protrusion is based on a principle applicable to a bolt and nut assembly when overloaded to the point of failure. The principle is simply that the failure should not consist of thread stripping. The preferred mode of failure is separation of the shank. Accordingly, nuts are manufactured to the precise height (thickness) which provides the necessary length of thread engagement to develop a stripping strength slightly greater than the tensile strength of its intended bolt. The bolt on the other hand has a chamfered end which resuls in the first two threads being smaller than the rest. These lead threads are to provide easier mating of the nut and bolt but are not intended for engagement because they do not provide a proper fit with the nut threads. The significance of the two lead threads changes with nut size and thread pitch variations. A 1 inch, UNF thread regular height nut, for example, contains 10.5 threads. In this nut, two threads account for 19 percent of the available thread. A 1/4 inch, UNC, regular height nut has only 4.4 threads; two threads would constitute 45 percent of the thread available for engagement.

In the case of nonmetallic insert self-locking nut types, the two-thread protrusion is required to insure that the thread lock engages only full sized threads, as it is designd to do. The lead threads do not provide the proper locking torque. Although there is no set limit to the number of protruding threads in excess of two, these should be kept at a practical minimum. Excess bolt length adds weight, cost more, and contributes nothing to the strength or locking ability of the nut-bolt set. If a bolt is too long, the nut may bottom out against the grip length (unthreaded portion) of the bolt before reaching its proper load.

Metal and non-metallic insert type locking nuts 3/8 inch and smaller may be checked by the "finger tight" method. If a nut can be run down with the fingers after the locking feature engages the bolt or stud, indicating the locking friction does not exist, it shall be replaced.

Finish requirements. Several types of finishes are used on aircraft nuts. The particular type of finish is dependent on the requirement and temperature application. The most generaly used types of finishes are described briefly as follows:

a. Cadmium plating. This is an electrolytically deposited silver-gray plating which provides exceptionally good protection against corrosion particularly in a salt atmosphere. It must be remembered that cadmium plated nuts are restricted for use in temperature applications not to exceed 450° F. When used in temperatures in excess of 450° F., the cadmium will diffuse into the base material causing it to become very brittle and subject to early failure.

b. Silver plating. Silver plating is applied to lock nuts for use at higher temperatures. Important advantages are its resistance to extreme heat (1400° F.) and its excellent lubricating characteristics. Silver gives high load carrying capacity and resists galling and seizing of mating parts when they are subjected to heat or heavy pressures.

c. Anodizing for aluminum. An inorganic oxide coating is formed on the metal by connecting the metals as anodes in a suitable electrolyte. The coating offers excellent corrosion resistance and can be dyed in a number of colors.

d. Solid film lubricant coating. Lock nuts are also furnished with molybdenum disulphide for lubrication purposes. It provides a clean, dry, permanently bonded coating to prevent seizing and galling of threads. Molybdenum disulphide is applied to both cadmium and silver plated parts.

Exercises (648):

1. When you install nuts, how many complete threads must protrude through the nut?

2. What installation principle dictates that a certain amount of thread protrusion is necessary?

3. What physical feature of an aircraft nut is directly related to the stripping strength of the nut?

4. Why are the first few threads on a bolt chamfered?

5. What types and sizes of aircraft can be checked using the "finder tight" method?

6. What would cause a cadmium plated nut to become brittle?

7. To overcome the problem stated in exercise 6, what would you do?

8. What process is used to make aluminum nuts corrosion resistance?

9. Why is a solid film lubricant coating added to nuts?

10. Which type of nut finish provides excellent protection against corrosion, particularly in a salt atmosphere?

649. Given a part number associated with aircraft nuts, identify individual portions of the part number.

Identification. Aircraft nuts are manufactured in a variety of shapes and sizes. They are made of cadmium-plated carbon steel, stainless steel, brass, or anodized 2024T aluminum alloy. They may be obtained with right- or left-hand threads.

Nuts do not come with the bolts when bolts are ordered; they come separated and must be ordered separately. No identifying marking or lettering appears on nuts. They are identified only by the characteristic metallic luster or color of the aluminum, the brass, or the nylon; by their construction; and by thread size.

Coding system. In stock lists, part numbers designate the type of nut. Here are the common types and the respective part numbers: plain, A315 and A335; castle, AN310; plain check, AN316; light hex, AN340 and AN345; and castellated shear, AN320. The patented self-locking types are assigned part numbers ranging from MS20363 through MS20367. The Boots, the Flexloc, the Elastic Stop Nut, and the steel self-locking nut belong to this group. Part number AN350 is assigned to the wing nut.

Letters and digits following the part number indicate such items as material, size, threads per inch, and whether the thread is right or left hand. The letter "B" following the part number indicates the nut material to be brass; a "D" indicates it to be 2017T aluminum alloy; a "DD" indicates it to be 2024T aluminum alloy; a "C", stainless steel; and a dash in place of a letter indicates the material to be cadmium-plated carbon steel. The digit (or two digits) following the dash or the material code letter is the dash number of the nut, and it indicates the size of the shank and threads per inch of the bolt on which the nut will fit. The dash number corresponds to the first figure appearing in the part number coding of general purpose bolts. A dash number 3, for example, indicates that the nut will fit an AN3 bolt (10-32); a 4 means it will fit an AN4 bolt (1/4–28); a 5, an AN5 bolt (5/16–24); and so on. (See fig. 4–13.) The code numbers for self-locking nuts end in three- or four-digit numbers. The last two digits refer to threads per inch, and the one or two digits preceding these two digits stand for the nut size in sixteenths of an inch.

AN315 OR AN335 = PLAIN NUT PART NUMBER
4 (4/16) = 1/4—28 SCREW AND THREAD SIZE
C = STAINLESS STEEL (CORROSION RESISTING)
R = RIGHT-HAND THREAD

THE COMPLETE CODE NUMBER FOR ORDERING THE PLAIN NUT WOULD BE AN315C4R

AN316 = PLAIN CHECK NUT PART NUMBER
4 (4/16) = 1/4—28 SCREW AND THREAD SIZE
C = STAINLESS STEEL
R = RIGHT-HAND THREAD

THE COMPLETE CODE NUMBER FOR ORDERING THE PLAIN CHECK NUT WOULD BE AN316C4R

SOME OTHER COMMON NUTS AND THEIR CODE NUMBERS ARE:

CODE NUMBER AN310DD5R
AN310 = AIRCRAFT CASTLE NUT
DD = 2024T ALUMINUM ALLOY
5 = 5/16 INCH IN DIAMETER
R = RIGHT HAND THREAD (USUALLY 24 THREADS PER INCH)

CODE NUMBER AN320—10
AN320 = AIRCRAFT CASTELLATED SHEAR NUT
= CADMIUM PLATED CARBON STEEL
10 = 5/8-INCH IN DIAMETER (THIS NUT IS USUALLY RIGHT-HAND THREAD, 18 THREADS PER INCH)

CODE NUMBER AN350B1032
AN350 = AIRCRAFT WING NUT
B = BRASS
10 = NUMBER 10 BOLT
32 = THREADS PER INCH

53-1756

Figure 4-13. Nut numbering system.

In stock lists, the full code number is given for each nut, and the corresponding bolt and thread size is also given in another column. If the description appears to need additional clarification, an illustration is included. This arrangement makes the stock list description quite complete and prevents errors in ordering nuts for bolts.

Exercises (649):
Identify the individual parts of the given nut part numbers by placing the specific portion of the parts number indicated by each listed factor.

1. Part Number - AN310DD5R
   a. Thread direction _____
   b. Bolt diameter _____
   c. Type nut _____
   d. Material composition _____
   e. Standard _____

2. Part Number - AN350B1032
   a. Material composition _____
   b. Type nut _____
   c. Bolt Size _____
   d. Thread size _____
   e. Standard _____

650. Match given characteristic factors to a specific style of aircraft nut.

Styles of aircraft nuts. Aircraft nuts come in a variety of styles to match the application requirements for a given area of the aircraft. The following are some of the ones you will most often use in your work.

a. Plate nuts. These nuts are used for blind mounting in inaccessible locations and for ease of maintenance. They are available in a wide range of sizes and shapes. One lug, two lug, and right-angle shapes are available to accommodate the specific physical requirements of the individual nut location. Floating type nuts provide a controlled amount of nut movement to compensate for subassembly misalignment. They can be either self-locking or plain. These nuts must be handled and installed carefully to prevent them from being deformed. Bases are countersunk for flush mounting, plain for modified welding, and equipped with nibs for projection welding. Figure 4-14 shows examples of both types—the floating and stationary.

b. Channel nuts. These nuts are used in applications requiring anchored nuts equally spaced around openings such as access and inspection doors and removable leading edges. Straight or curved channel nut strips offer a wide range of nut spacings and provide a multiple nut unit that has all the advantages of float-type nuts. They are usually self-locking. Figure 4-15, shows two types with different nut spacings and grip lengths.

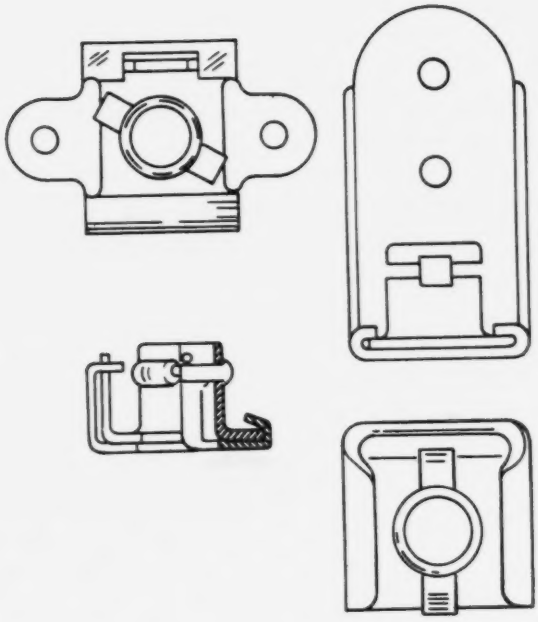
Channel nut assemblies are fabricated in both steel and aluminum alloy compositions. Installation consists of riveting the assembly to the structure using 3/32 of an inch solid rivets or steel pull-thru blind rivets. Individual nuts can be replaced by spreading the channel slightly, snapping out the nut, and replacing it with a new one. Care must be taken not to crack or distort either the channel or surrounding structures.

c. Barrel nuts. These nuts are installed in regular, drilled holes. The round portion of the nut fits in the drilled hole providing a self-wrenching effect. They are usually self-locking.

d. Internal wrenching nuts. These nuts are generally used where a nut with a high tensile strength is required or where space is limited and the use of external wrenching nuts would not facilitate the use of conventional wrenches for installation and removal, usually where the bearing surface is counterbored. These nuts have a nonmetalic insert which provides a locking action. They are usually self-locking.

e. Point wrenching nuts. These nuts are generally used where a nut with a high tensile strength is required. These nuts are installed with a smaller socket wrench than would normally be used for a hexagon nut. They are usually self-locking.

f. Shear nuts. These nuts are designed for use with devices such as drilled clevis bolts and threaded taper pins which are normally subjected to shearing stress only. They are usually self-locking.



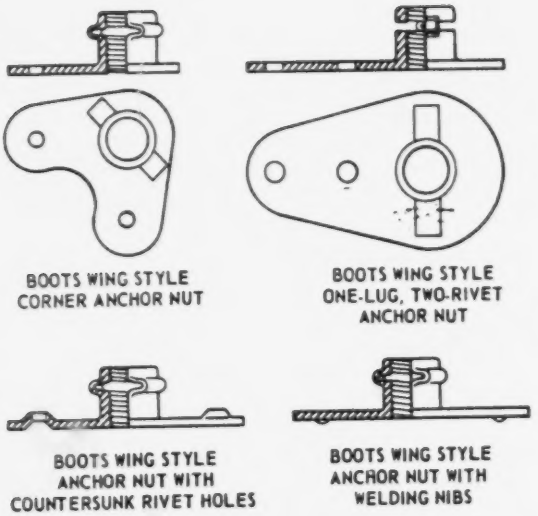

BOOTS WING STYLE CORNER ANCHOR NUT
BOOTS WING STYLE ONE-LUG, TWO-RIVET ANCHOR NUT
BOOTS WING STYLE ANCHOR NUT WITH COUNTERSUNK RIVET HOLES
BOOTS WING STYLE ANCHOR NUT WITH WELDING NIBS
STATIONARY NUT PLATES
53-1751

Figure 4-14. Types of plate nuts.

Exercises (650):
Match the styles of nuts listed in Column 1 to the specific factor listed in Column 2 by placing the letter or letters of the nuts in the space provided in front of each feature.

Column 1	*Column 2*
a. Plate nut.	1. _____ Requires smaller sizes wrenches to install.
b. Channel nut.	2. _____ Used with Clevis bolts.
c. Barrel nut.	3. _____ Install in regular drilled holes.
d. Internal wrenching nut.	4. _____ Used when high tensile strength is required.
e. Point wrenching nut.	5. _____ Bearing surface is usually countersunk.
f. Shear nut.	6. _____ Used in inaccessible locations.
	7. _____ Can be welded in place.
	8. _____ Multiple nut assembly.
	9. _____ Nonconventional wrenches are used.
	10. _____ Used with taper pins.

651. Identify types of non-self-locking aircraft nuts.

Types of non-self-locking aircraft nuts. Non-self-locking aircraft nuts are those which must be safetied by external locking devices such as lock nuts, cotter pins or safety wire. Most of the familiar types of nuts, including the plain nut, the castle, the castellated shear nut, the plain hexnut, the light hexnut, and the plain check nut are of the non-self-locking type and are illustrated in figure 4-16.

- The castle nut, AN 310, is used in conjunction with drilled-shank AN hexhead bolts, clevis bolts, eyebolts, drilled head bolts, or studs. It is fairly rugged and can withstand large tensional loads. Slots (called castellations) in the nut are designed to accommodate a cotter pin or lock wire for safetying purposes.
- The castellated shear nut, AN 320, is used with devices (such as drilled clevis bolts and threaded taper pins) which are normally subjected to shearing stress only. Like the castle nut, it is castellated for safetying. Note, however, that this nut is not as deep or as strong as the castle nut; also that the castellations are not as deep as those in the castle nut.
- The plain hexnut, AN315 and AN335 (fine and coarse thread), is of rugged construction. This makes it suitable for carrying large tensional loads. However, since it requires an auxiliary locking device, such as a check nut or lockwasher, its use on aircraft structures is somewhat limited.
- The light hexnut, AN340 and AN345 (fine and coarse threads), is a much lighter nut than the plain hex and must be locked by an auxiliary device. It is used for miscellaneous light-tension requirements.
- The plain nut, AN316, is employed as a locking device for plain nuts, set-screws, threaded rod ends, and other devices.
- The wing nut, AN350, is used where the desired tightness can be obtained with the fingers and where the assembly is frequently removed.

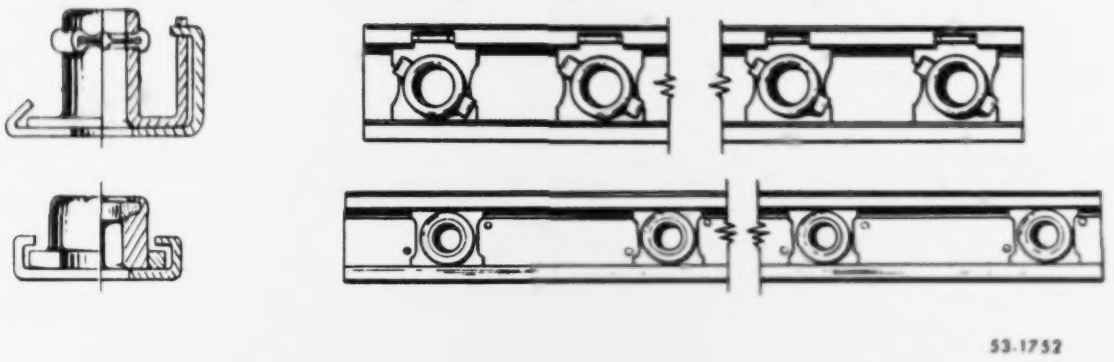


Figure 4-15. Gang channel nuts.

Exercises (651):

In the space provided, write in the name of the t ype of non-self-locking aircraft nut described in the statement.

1. It is fairly rugged and can withstand large tensional loads; contains slots; not used in shear applications. _____
2. It is used where an assembly is frequently removed. _____
3. Employed as a locking device for set screws. _____
4. Used for miscellaneous minor tension requirements. _____
5. It is suitable for carrying large tensional loads, requires an auxiliary locking devices, and has no slots. _____
6. Used primarily with clevis bolts and threaded taper pins. _____

652. Differentiate between two major types of self-locking nuts.

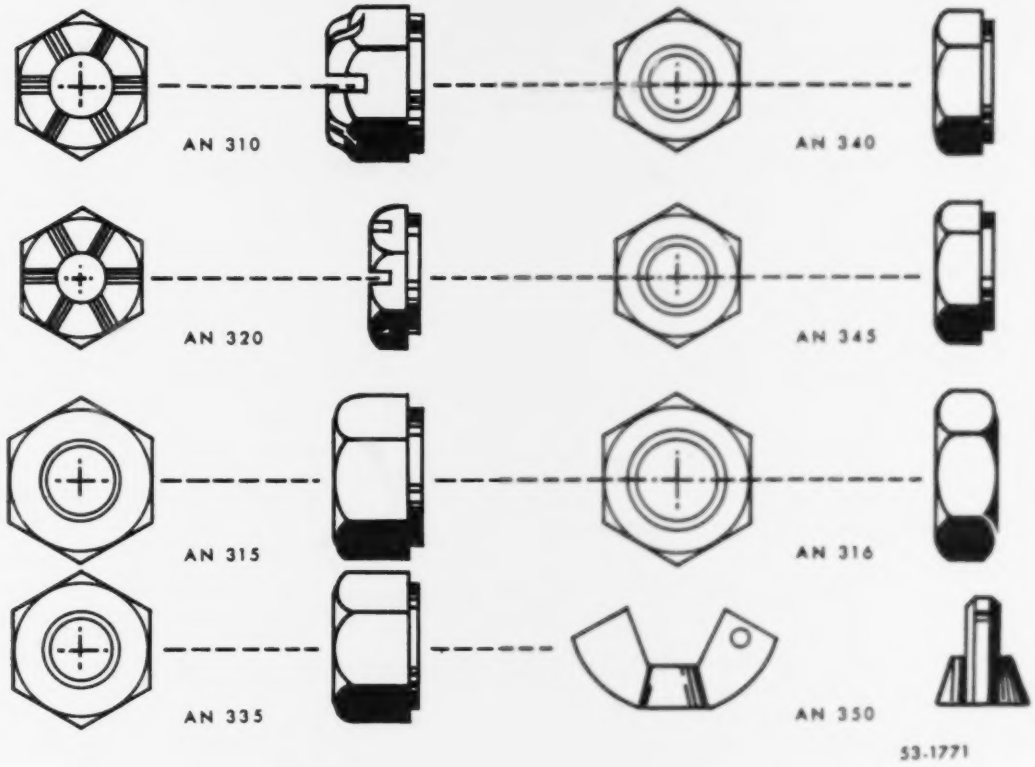


Figure 4-16. Types of non-self-locking nuts.

Self-locking aircraft nuts. As their name implies, self-locking nuts need no auxiliary means of safetying but have a safetying feature included as an integral part of their construction. They are used in aircraft to provide connections which will not shake loose under severe vibration. So many types of self-locking nuts have been designed that their use has become quite widespread. Common applications are attachment of antifriction bearings and control pulleys; attachment of accessories, as anchor nuts around inspection holes and small tank installation openings; and attachment of rocker box covers and exhaust stacks.

Nearly all self-locking nuts used by the Air Force are of steel or aluminum alloy. However, such nuts are available in practically any kind of metal. Aluminum alloy self-locking nuts are supplied with an anodized finish. Steel nuts are cadmium plated. The two major types of self-locking nuts in use are the prevailing torque type and the free-spinning type.

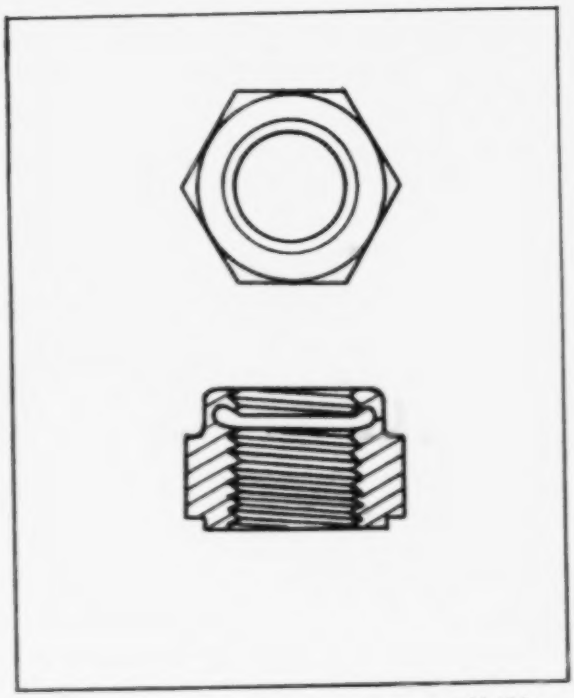
a. Prevailing torque type. The prevailing torque nuts usually incorporate one of the following locking elements:

(1) Nonmetallic inserts. These nuts have a nylon insert of smaller inside diameter than bolt major diameter, which exerts a compressive locking force against the bolt. (Nonmetallic nuts formerly had a fiber insert; however, fiber nuts are no longer procured for AF use). If these nuts are reused, they shall be checked to see if the locking insert has lost its locking friction or become brittle. The nonmetallic, locking insert shall never be tapped. Nonmetallic insert, self-locking nuts shall not be subjected to temperatures in excess of 250° F. in accordance with Military Specification MIL-N-25027.

(2) Slotted or beam nut. This type nut has a tapered and slotted (or split) top. Each portion between slots acts as a beam and is depressed inward to form a functional locking element.

(3) Deformed thread type. This type nut has a portion of the threads formed in an oval, triangular, or square shape rather than round; locking is accomplished by the frictional force developed when the bolt forces these threads into a round shape.

(4) Interrupted thread type. This nut is basically two nuts combined. The lower portion carries the load while the top provides the locking. The top threads are offset axially downward so that they do not coincide exactly with an imaginary extension of the lower threads. When a bolt enters the top portion, it springs these threads into the correct position and the springing action locks the nut. Figure 4-17 shows the internal design of this type of nut.



53-1754

Figure 4-17. Interrupted thread type nut.

The *Boot self-locking nut* is an all metal prevailing torque nut which incorporates an interrupted thread design. Note in figure 4-18 that it has two sections and is essentially two nuts in one—a locking nut and a load-carrying nut. The two sections are connected with a spring which is an integral part of the nut. The spring keeps the locking and load-carrying sections such a distance apart that the two sets of threads are out of phase; that is, so spaced that a bolt which has been screwed through the load carrying section pushes the locking section outward against the force of the spring to engage the threads of the locking section.

The spring, through the medium of the locking section, exerts a constant locking force on the bolt in the same direction as a force that tightens the nuts. In Boots self-locking nuts, then, the load-carrying section has the thread strength of a standard nut of comparable size; the locking section presses against the threads of the bolt and locks the nut firmly in position. Only a wrench applied to the nut will loosen it. The nut can be removed and reused without impairing its efficiency.

Boots self-locking nuts are made with three different spring styles and in various shapes and sizes: (1) the wing type, which is the most common, ranges from size number 6 to 1/4 inch; (2) the Rol-top ranges from 1/4 to 9/16 inch; and (3) the bellows type ranges from size number 8 to 3/8 inch. Wing nuts are made of anodized aluminum alloy, cadmium-plated carbon steel, or stainless steel. The Rol-top nut is cadmium-plated steel, and the bellows type is made of aluminum alloy only.

The *elastic stop nut* is a standard nut with the height increased to accommodate a nylon lock collar. Note in figure 4-19 that the nylon locking collar is not threaded and that its inside diameter is smaller than the largest diameter of the threaded portion or the outside diame-

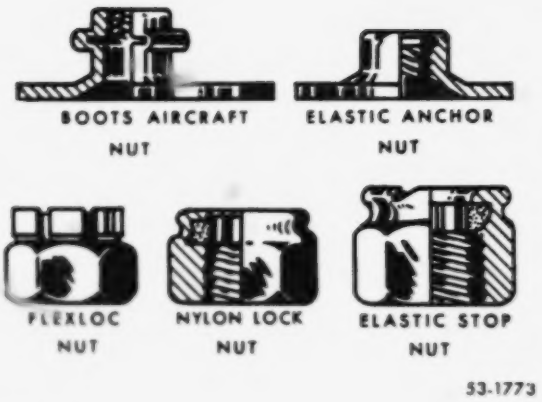


Figure 4-18. Self-locking nuts.

ter of a corresponding bolt. When the nut is screwed onto a bolt, it acts as an ordinary nut until the bolt reached the nylon collar. When the bolt is screwed into the nylon collar, however, friction (or drag) causes the nylon to be pushed upward. This creates a heavy downward pressure on the load-carrying part and automatically throws the load-carrying sides of the nut and bolt threads into positive contact. After the bolt has been forced all the way through the nylon collar, the downward pressure remains constant. This pressure locks and holds the nut securely in place even under severe vibration.

Elastic stop nuts range from size number 1 to size number 27 for machine screws, and from 1/4 inch to 6 inches for large bolts. All are made with standard type threads. Whatever the shape of the nut, the locking principle is the same.

b. Free-spinning type. The free-spinning type turns freely until seated; then further tightening results in a locking action. This type nut consists of a split, tapered, threaded core keyed into a metal shell with mating tapered core. The small end of the taper is at the bottom of the nut. When the outer shell contacts the bearing surface of the mating part, further rotation of the nut (tightening) forces the core downward to produce collect-type locking action. It is free-spinning on until contact is made with the bearing surface, and free-spinning off after being backed away from the bearing surface.

The stainless steel self-locking nut, figure 4-20, is an excellent example of a free-spinning type nut. The stainless steel self-locking nut may be spun on and off with the finger, as its locking action takes place only when the nut is seated against a solid surface and tightened. The nut consists of two parts; a case with a beveled locking shoulder and key, and a threaded insert with a locking shoulder and slotted keyway. From the cross-sectional view in figure 4-20, you can see that the key of the case fits into the slotted keyway of the insert so that when the case is turned the threaded insert is turned with it. Note that the slot is wider than the key. This permits the slot to be narrowed and the insert to be compressed when the nut is tightened.

Until the nut is tightened, it spins on the bolt easily, because the threaded insert is the proper size for the bolt. Howeer, when the nut is seated against a solid surface and tightened, the locking shoulder of the insert is pulled downward and wedged against the locking shoulder of the case. This action compresses the threaded insert and causes it to clench the bolt tightly. You can see what has happened by looking at the cross-sectional view of the locked nut in figure 4-20 and noticing how the slotted keyway has been narrowed as a result of the compression of the threaded insert.

Exercises (652):
From the following listed features, construct two listings. Place the numbers of the features that pertain to the prevailing torque type nuts in one list and place the numbers of the features that pertain to the free-spinning type nuts in the second list. Headings are provided after the listing.

Features
1. Nylon inserts are used as locking elements.
2. Portions of the threads may be oval in shape.
3. Threaded core keyed into a metal shell.
4. Tightens only after surface contact is made.
5. One style is basically a two nut combination.

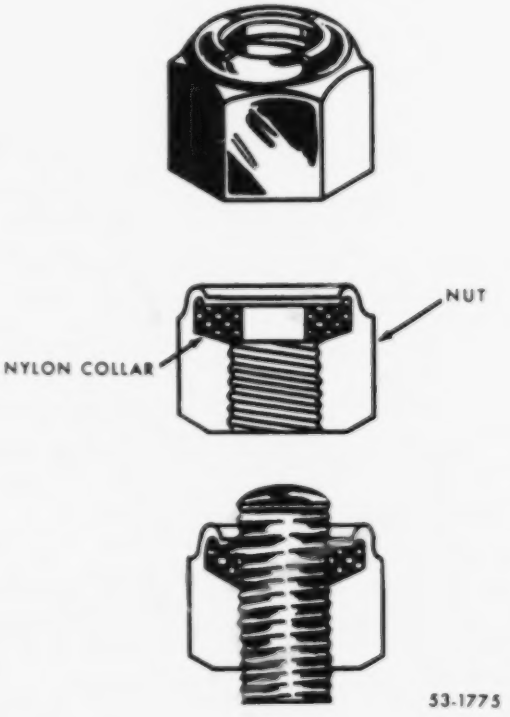


Figure 4-19. Elastic stop nut.

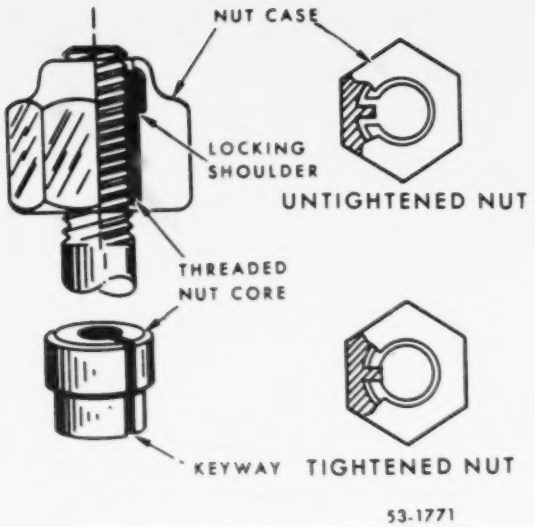


Figure 4-20. Stainless steel self-locking nut.

6. Insert the same diameter as bolt.
7. Locking element is tapered and slotted at top.
8. Nut consists of two parts.
9. Locking action is described as a collect-type locking action.
10. The bellows type is made of aluminum alloy only.
11. Easily removed after being backed away from the bearing surface.
12. Top threads are off-set axially downward.

1. Prevailing torque type nuts -

2. Free-spinning type nuts -

653. Distinguish between true and false statements related to the precautions you must observe when installing aircraft nuts.

Installing aircraft nuts. Regardless of the type of nut you are using, always select the correct tool to install it. Socket and box-end wrenches are preferred to open-end wrenches because they do not round the corner of the nut. The precautions that you must observe will be directly influenced by the type nut you are installing.

a. Installing the prevailing torque type. Most of the precautions associated with prevailing torque nuts centers around the nonmetallic insert type. The following are some of the precautions to practice:

- Do not use bolts with burrs around cotter pin holes. The rough edges will tear the nylon collar as the bolt passes through it, and this action will eventually reduce the self-locking action. Use bolts without cotter pin holes whenever possible.
- Do not use sawed-off bolts that have rough ends. If sawed-off bolts are used, file off the burrs before applying the nut.
- Never tap the nylon collar. The self-locking action of the elastic stop nut is the result of having the bolt threads impress themselves into the untapped nylon.
- When reusing elastic stop nuts, be sure the nylon has not lost its locking friction or become brittle.

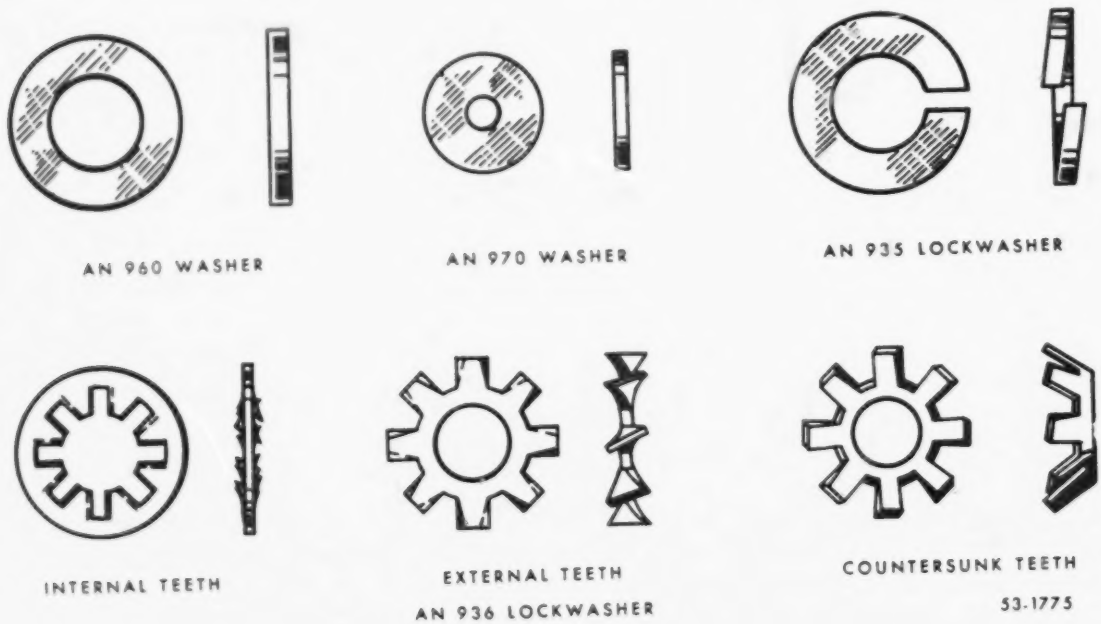


Figure 4-21. Types of aircraft washers.

If a nut can be turned with the fingers, replace it.

b. Installing the free-spinning type. Due to the lack of nonmetallic inserts, the precautions for the free-spinning nuts are limited to areas of installation and torque requirements. Observe the following precautions:

- Free-spinning nuts were designed for exhaust flange attachments and shall be used only as specified in the applicable technical orders for the equipment affected. These nuts are not considered suitable for general aerospace vehicle use.
- The minimum acceptable torque required to remove a free-spinning nut when in the locked position is 10 inch-pounds torque. Any of these nuts that requires less than 10 inch-pounds torque to break away when in the locked position shall be disposed of. If the nuts have been correctly torqued, they may be reused, provided there is no indication of internal or external deformation or damage.

c. General precautions—both types. New self-locking nuts shall be used each time components are installed in critical areas throughout the entire aerospace vehicle including all flight, engine, turbopropeller, and fuel control linkage and attachments. New self-locking nuts shall be used in any application of the aerospace vehicle where vibration could cause loosened nuts to be ingested by the engine.

Self-locking nuts shall not be used at joints in control systems of aerospace vehicle structure when movement of the joint may result in motion of the nut relative to the surface against which it is bearing. They may be used with antifriction bearings and control pulleys provided the inner race of the bearing is clamped to the supporting surfaces by the nut and bolt. The nuts which are attached to the structure shall be attached in a positive manner to eliminate the possibility of their rotating or misaligning when the tightening is to be accomplished by rotating the bolts or screws. The manner of attachment must permit removal without injury to the structure and the replacement of the nuts.

Temperature limitations must also be considered when installing aircraft nuts. Guidelines are:

a. Non-metallic insert nuts are limited to 250° F.

b. Cadmium plated nuts are limited to 450° F. These nuts have a whitish color and bright luster when new.

c. Corrosion resistant or stainless steel nuts are limited to 800° F. There should be no problem in recognizing stainless steel nuts. This nut may be coated with silver flashing, which gives the nut a yellowish color and dull luster.

c. 1200° F. nuts are also silver coated or plated. There is no general rule which can be followed in identifying the 800° F. nut with silver coating from the 1200° F. nuts except in some cases the number 12 may be stamped on one hex.

Exercises (653):

1. In the space provided in front of each statement, indicate whether the statement is true or false by placing the letter T or F. All statements relate to the installation of aircraft nuts.

a. _____ Open-end wrenches are preferred when tightening aircraft nuts.
b. _____ Never tap elastic stop nuts.
c. _____ When nylon inserts have lost their locking feature, heat to 250° before reusing.
d. _____ Free-spinning nuts are not suitable for general use.
e. _____ Nuts should not be installed on bolts that have been cut to length.
f. _____ Any free-spinning nut that requires less than 10 inch-pounds torque to remove, should be replaced.
g. _____ Elastic stop nuts that have been subject to a temperature of 200° F. should be replaced.
h. _____ Stainless steel nuts can be used in areas where the temperature is limited to 800° F.
i. _____ A nut with the number 12 stamped on it, indicates that 12 inch-pounds of torque is required when installed.
j. _____ For temperatures ranges between 200° F. and 400° F. a cadmium plated nut is required.

2. Based on your answer to exercise 1, state the correct procedures to use for all the false statements.

654. Given work situations, select the proper type aircraft washer to use.

Aircraft washers. Washers used in airframe repair are either plain, lock, or special type washers.

Plain washers. Plain washers, shown in figure 4-21, both the AN960 and AN970, are used under AN hexnuts. They provide a smooth bearing surface and act as a shim to obtain correct grip length for a bolt and nut assembly. They are used to adjust the position of castellated nuts in respect to drilled cotter pin holes in bolts. Plain washers are used under lock washers to prevent damage to the surface material.

Aluminum and aluminum alloy washers are used under bolt heads or nuts on aluminum alloy or magnesium structures where corrosion caused by dissimilar metals is a factor. Then any electrical current flow will be between the washer and the steel bolt. However, it is common practice to use a cadmium-plated steel washer under a nut bearing directly against a structure. This washer will resist the cutting action of a nut better than an aluminum alloy washer will.

The AN970 steel washer has a greater bearing area than the AN960 washer. It is used on wooden structures under both the head of a bolt and the nut to pre-

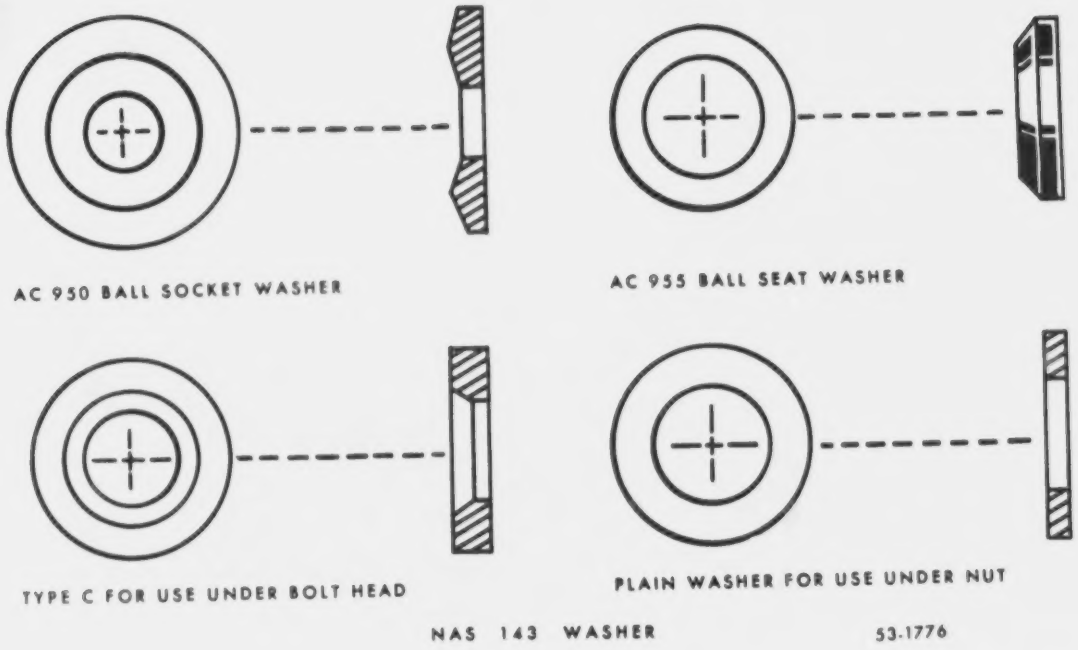

AC 950 BALL SOCKET WASHER
AC 955 BALL SEAT WASHER
TYPE C FOR USE UNDER BOLT HEAD
PLAIN WASHER FOR USE UNDER NUT
NAS 143 WASHER
53-1776

Figure 4-22. Ball-socket and ball seat washers.

vent crushing the surface. Brass nonstructural washers, AN961, are used in electrical components and instrument mountings where nonmagnetic properties are required.

Lock washers. Lock washers, both the AN935 and AN936, are used with machine screws or bolts where the self-locking or castellated type nut is not appropriate. The spring action of the washer provides enough friction to prevent loosening of the nut from vibration (see fig. 4-21).

Lock washers are not used under the following conditions:

- As fastenings to primary structures.
- As fastenings on any part of the aircraft where failure might result in damage or danger to the aircraft or personnel.
- Where failure would permit the opening of a joint to the airflow.
- Where the screw is subjected to frequent removal.
- Where the washers are exposed to the airflow.
- Where the washers are subjected to corrosive conditions.
- Where the washer is against soft material without a plain washer underneath to prevent gouging the surface.

Lockwasher may be used to prevent the loosening of threaded fasteners under the following conditions.

a. When a self-locking feature cannot be provided in externally or internally threaded parts.

b. When a cotter pin cannot be used to prevent rotation of an internally threaded part with respect to an internally threaded part.

c. When lock wire cannot be used to prevent loosening of threaded parts.

d. When the fastening is not used for fabrication of primary structure.

e. When loosening of threaded parts would not endanger the safety of the airplane or personnel.

f. When corrosion, encouraged by gouging of aluminum or magnesium alloys by edges of teeth on AN936, would not cause malfunctioning of parts being fastened together. Corrosion of dissimilar metals may be reduced by installing AN936 washers with wet primer.

Special washers. There are many types and varieties of special washers used in a multiplicity of applications. The following are just a few of the ones you will use in your work.

a. Ball-socket and ball seat washers. The ball-socket and seat washers, AC950 and AC955, are special washers used where a bolt is installed at an angle to a surface, or where perfect alignment with a surface is required. These washers are used together. They are shown in figure 4-22.

b. Taper pin washers. Taper pin (dished) washers are used in conjunction with threaded taper pins, and are installed under the cut to effect adjustment where a plain washer would distort.

c. High tensile washers. High tensile washers, MS20002, are used in conjunction with high tensile internal wrenching bolts, MS20004 through MS20024.

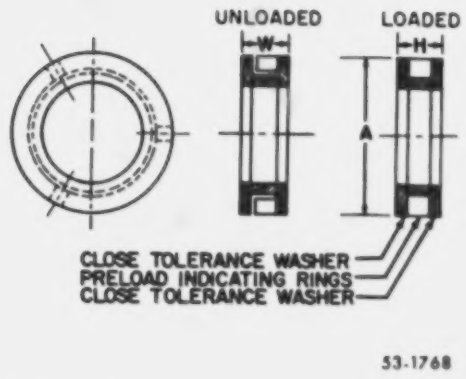


Figure 4-23. Preload indicating washers.

Type C, figure 4-22, washer is countersunk to seat the bolthead shank radius, and a plain type washer is used under the nut. Plain and countersunk high tensile washers, MS20002 and MS20002C, are heattreated to 125,000 to 145,000 psi.

d. Countersunk washers. Countersunk washers, commonly called dimpled washers, are for use with 100°, flathead screws or rivets to provide reinforced low-profile attachments in such locations as fillets and other fairing installations.

e. Preload-indicating washers. Preload-indicating washers are used under nuts and provide a means of measuring the torque applied to a tightened nut. The preload-indicating washer consists of two concentric steel rings between two close-tolerance washers. The inner ring is attached to the two washers. The inner ring is compressed until the loose outer ring is bound between the two washers. The inner ring has a constant resistance to deformation; therefore, the force necessary to compress the inner ring is predetermined and is equal to the torque applied to the nut. The exact predetermined torque has been reached when binding of the outer ring occurs. The pre-load indicating washer can be used only one time for measuring torque. Figure 4-23 shows the individual parts and how the washer looks unloaded and loaded.

Exercises (654):

1. What type of washer would you use under the head of a bolt on a wooden structure?

2. When replacing a fillet or a fairing assembly, you would most likely be using what type of washers?

3. To seat the shank radius of an internal wrenching bolt, you would use what type of washer?

4. To measure the torque on a previously installed preload indicating washer, what actions would you employ?

5. When it is permissible to use lock washers on aluminum and magnesium alloys, without the use of a plain washer, how can corrosion be reduced?

4-2. Types of Special Hardware

The term "special hardware" refers to those types of fastening devices not included in the basic classes of hardware, such as rivets, bolts, turnlock fasteners, etc. Fastening devices such as hinge assemblies, structural quick-release type latches, and the nonstructural quick release type latches are grouped as special hardware. These types of hardware are normally used on an aircraft. Our discussion will be directed towards the nonstructural quick-release type latches and the types of hinge assemblies. The reason for this is that these are the ones you will repair or replace most often.

655. Given data related to the installation of nonstructural quick-release type latches, determine the proper procedure to use.

Nonstructural quick-release latches. The nonstructural quick-release type latches shown in figure 4-24, is the type most often used today. Not only is this type latch found on aircraft, it is also used in large numbers on aerospace ground equipment. This latch incorporates a spring-loaded press-release type mechanism. They are available in various styles and shapes fabricated from steel alloys. The latch consists of three basic parts: an attachment plate, a release button, and a spring loaded locking arm.

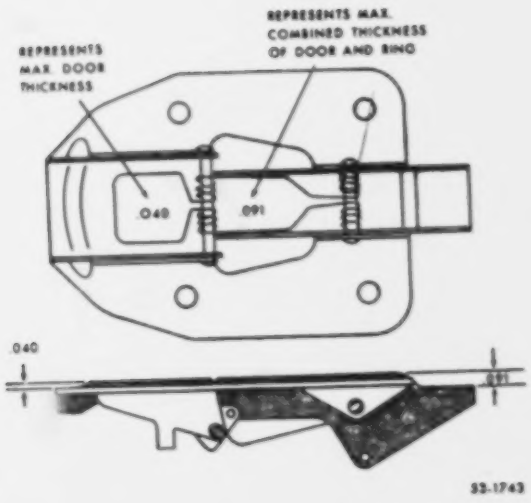


Figure 4-24. Nonstructural quick release type latch.

The attachment plate contains a cutout area equal to the head portion of the release button and the width of the locking arm. The attachment plate comes predrilled and is riveted to the access panel or door. The release button and the locking arm are hinged to the attachment plate, completing the latch assembly. The release button holds the locking arm in a locked position when the latch is fastened. The front edge of the release button is hinged so that when pressed, the locking arm is released, unfastening the latch. The locking arm has an indented section which extends beyond the front edge of the attachment plate. This indented section is what locks the access panel or door in place, when the locking arm is pressed into the cutout area on the attachment plate.

Selection factors. Two factors must be known to correctly select the size latch required—the thickness of the access panel or door and the access retaining ring. Numbers are stamped on the bottom side of the latch representing the thickness requirements of a given latch. In figure 4-24, the latch shown is for an access door or panel 0.040 of an inch thick and has a locking capacity of 0.091 of an inch. The right size latch must always be used. Oversized latches will not securely clamp the access door or panel in position and undersize latches will not fasten.

Installation factors. Figure 4-25, shows a typical latch installation in an access panel. Key points to remember when installing this type latch are these:

- The cutout in the access panel must permit the release button and locking arm to operate without binding. An attachment plate from a broken latch can be used as a template to obtain the cutout dimensions for making cutouts.
- Exercise extreme care when riveting the latch to the access panel so that you do not damage the hinge points of the release button or the locking arm.
- After installation, check the operation of the latch. A minimum amount of pressure should be required to operate the latch. An excessive amount of pressure will indicate that the latch was installed improperly.

Exercises (655):

1. When making a cutout on an access panel for a quick-release type latch, what can be used to reduce the chances of making too large or too small a cutout?

2. If you are required to replace a missing quick-release type latch, what factors must you know before selecting a replacement?

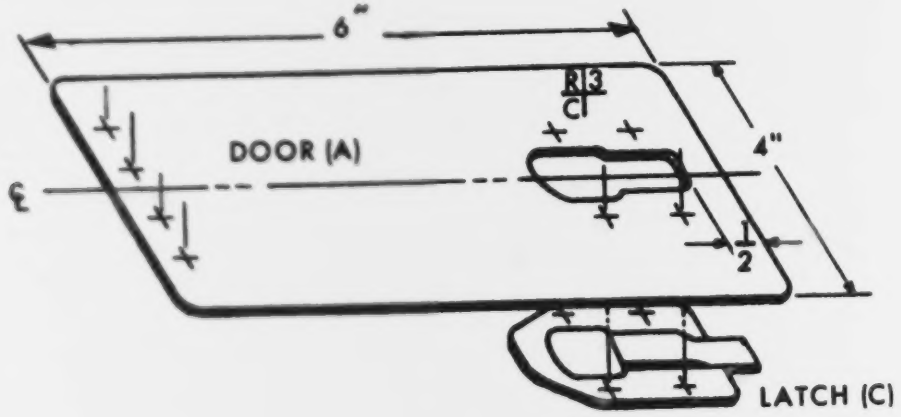


Figure 4-25. Typical latch installation.

3. If after installing a quick-release type latch, it operates freely but the panel is loose, what is most likely the cause of the panel being loose?

4. What results when an undersized quick-release type latch is installed?

5. What method of hole location is used to locate new rivet holes for a quick-release type latch?

656. Given characteristics related to the types of aircraft hinges, name the specific type of hinge.

Aircraft Hinges. Hinge asemblies used on an aircraft are classified into two types: the formal-type and the extruded type. The function of the structure they are installed on will determine the type hinge used.

Formed hinge Formed hinges are used in nonstructural applications. They are fabricated from aluminum and steel alloys. A formed hinge assembly consists of two flanges (flats) which have equally spaced rolled lobes (tangs) on one side, through which a steel pin is inserted. By the insertion of a steel pin, a hinge assembly is developed. Formed hinges are available in different thicknesses and flange widths. Replacement hinge assemblies usually are manufactured in standard lengths of 6 feet. You will have to cut the needed length from this. A formed hinge assembly is shown in figure 4-26.

Extruded hinge. Extruded hinges are used in structural applications. They are stress carrying members of the structure to which they are attached. A section of a flat-type extruded hinge assembly consists of two extruded flanges (flats) which incorporates extruded lobes (tangs) through which the hinge pin is inserted. The upper portion of figure 4-26, shows an end-view comparison between the formed hinge and the extruded hinge. Various styles of extruded hinges besides the flat design are found throughout an aircraft. Some incorporate two hinge pins with a flat section between them to allow further opening of a panel or door. The flat design type is available in 6 foot lengths also.

When working with hinge assemblies certain factors and procedures must be employed.

- Do not substitute a formed hinge for an extruded hinge.
- The placement of the lobes, whether facing inward or outward, will directly affect how far an access panel or door will open.
- Hinge assemblies should be cut to needed lengths with a hacksaw.
- Some method of hinge pin retention must be used at both ends of the hinge assembly.
- Hinge pin holes should not be reamed for a larger size pin, except when permitted by specific TO instructions.
- Corrosion prevention methods are extremely important because hinges are a natural trap for dirt, salt, and moisture.

Exercises (656):

In the space provided at the end of each statement, write in the type of hinge, the procedures, or characteristic described in the statement.

1. A nonstructural hinge assembly. _____
2. A structural hinge assembly. _____
3. Consist of rolled hinge lobes. _____
4. Could be used as a substitute when the hinge assembly for a nonstructural access door is missing. _____
5. Found on a stress carrying access panel. _____

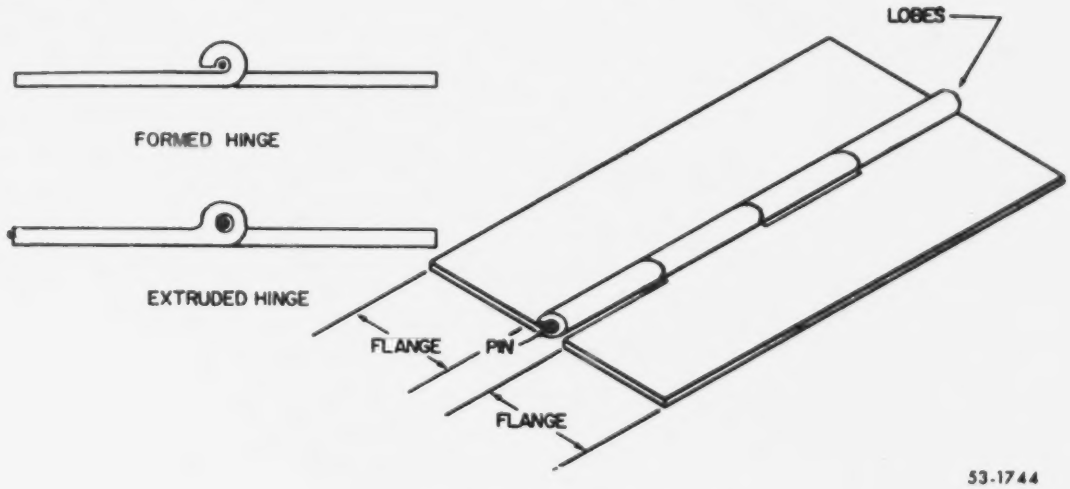


Figure 4-26. Hinge assembly-formed type.

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NOTE: None ot the items listed in the bibliography above are available through ECI. If you cannot borrow them from local sources, such as your base library or local library, you may request one item at a time on a loan basis from the AU Library, Maxwell AFB, AL 36112, ATTN: ECI Bibliographic Assistant. However, the AU Library generally lends only *books* and a limited number of *AFMs*. TOs, classified publications, and other types of publications are not available.

Answers For Exercises

CHAPTER 1

Reference:

600 - 1. The plug section of the stem provides the shear strength to (friction lock) blind rivets.
600 - 2. Magnesium.
600 - 3. Weight.
600 - 4. To provide the necessary material to form the shop head on the blind side.
600 - 5. 1/4 of an inch.
600 - 6. 32nds of an inch.
600 - 7. Oversized (friction lock) blind rivets have a blue colored sleeve.
600 - 8. Only when absolutely necessary.
600 - 9. Because of the loss of shear strength that would result.
600 - 10. One size diameter (friction lock) blind rivet larger than the solid rivet replaced should be used.

601 - 1. 90 to 100 psi.
601 - 2. 0.002 to 0.004 thousandths of an inch.
601 - 3. #20.
601 - 4. The diameter of the rivet being installed.
601 - 5. A twist drill of the same size as the rivet shank is used.

602 - 1. When a minimum of 60 percent of the rivet head is bearing against the surface of the hole.
602 - 2. The measurement should be taken at the rivet shank.
602 - 3. The gap should not exceed 5 percent of the thickness of the thinnest part of a riveted assembly.
602 - 4. When incorrect rivet installation is suspected.
602 - 5. Proper grip length and hole diameter.

603 - 1. A mechanical lock blind rivet has a separate locking collar.
603 - 2. Trimming the stem flush with the head of the rivet.
603 - 3. Standard type.
603 - 4. Bulbed type.
603 - 5. The diameter sizes of the bulbed type rivets.
603 - 6. By head markings stamped on the manufactured head.
603 - 7. They are the same.
603 - 8. The grip range.
603 - 9. They are equal in strength.
603 - 10. In areas where it would be hazardous if the stem or locking collar were to fall out of the rivet, such as in an engine intake or an electronic area.

604 - 1. Use the installation tools of the manufacturer of the rivets being installed.
604 - 2. Factors such as the quantity of rivets to be installed, the accessability of the work area, the availability of air supply, and the size and type of rivets you are installing.
604 - 3. After the locking collar is locked in the conical recess of the manufactured head.
604 - 4. The diameter of the bulbed type mechanical lock blind rivets are 1/64 of an inch larger than the standard type mechanical lock blind rivets.
604 - 5. The area, if possible, should be backed up during the first stages of the removal process.
604 - 6. A hollow drift pin.
604 - 7. Microshaver.

605 - 1. Insufficient grip length.
605 - 2. Above the manufactured head.
605 - 3. 0.002 of an inch.
605 - 4. 0.006 of an inch.
605 - 5. None.

606 - 1. Pull-thru rivets are far below the structural strength of solid shank rivets.
606 - 2. Replace hardware such as nut plates.
606 - 3. So that rivet shank will not swell between the matting surfaces.
606 - 4. The length of the rivet and the material thickness of the part being riveted.
606 - 5. Hand-start the required screw of bolt used in the nut plate checking the nut plate alignment and rivet installation.
606 - 6. The countersunk or dimpled holes.

CHAPTER 2

607 - 1. Pin and locking collar.
607 - 2. Hi-Shear rivets are about 40 percent lighter in weight; they require only about one-fifth as much time for installation, and they are as strong as bolts of equal diameter.
607 - 3. Hi-Shear are three times as strong as an equal diameter solid rivet.
607 - 4. Area of installation, strength requirements, and composition of the material being fastened.
607 - 5. Diameter is measured in 1/32 of an inch; the grip length is measured in 1/16 of an inch.
607 - 6. The straight portion of the Hi-Shear pin should not extend more than 1/16 of an inch beyond the material.
607 - 7. Countersunk and flat head styles.
607 - 8. Head markings on the top of the pin.
607 - 9. To allow a longer than required Hi-Shear pin to be used when the proper grip length Hi-Shear pin is not available.

608 - 1. Hi-Shear rivets do not expand during installation.
608 - 2. When the surface is not level.
608 - 3. When the surface is not perpendicular to the centerline of the rivet hole by more than 5° or when the radius of the curved surface under the collar is less than three times the diameter of the pin.
608 - 4. Gaps are formed between the head and the countersunk holes.
608 - 5. When space limitation requires the Hi-Shear fastener to be driven from the manufactured side.
608 - 6. Use a longer length pin.
608 - 7. It must be below the top of the collar.
608 - 8. These actions produces an unsatisfactory installation.

608 - 9. Tensile strength is reduced.
608 - 10. Chisel method.

609 - 1. Stump, pull, and blind.
609 - 2. They are used mainly in the primary and secondary structures of an aircraft.
609 - 3. Pull type lockbolts are one-half the weight of equivalent AN steel bolts.
609 - 4. Tension lockbolt pins have larger and thicker head sizes and more locking grooves than shear lockbolt pins.
609 - 5. When clearance does not permit the installation of pull type lockbolts.
609 - 6. Heat-treated alloy steels and high-strength aluminum alloys.
609 - 7. Lockbolt diameters are measured in 1/32 of an inch increments and the grip length is measured in 1/16 of an inch increments.
609 - 8. Hi-Shear rivets, solid steel rivets, and steel and 2024-T aluminum alloy bolts of the same diameter.
609 - 9. The different colors indicate material composition of the collars.
609 - 10. Heat-treated alloy steel pin, blind and filler sleeve, a mild steel collar, and a carbon steel washer.

610 - 1. The rivet set for Hi-Shear rivets has an ejection port, whereas the rivet set for stump lockbolts does not have one.
610 - 2. CP 352.
610 - 3. CP 353.
610 - 4. The material must be tightly clamped together.
610 - 5. Aluminum washer.
610 - 6. Interference fit refers to holes drilled slightly smaller than the diameter of the fastener being installed.
610 - 7. Clearance fit refers to holes drilled slightly larger than the diameter of the fastener being installed.
610 - 8. Step-drilling.
610 - 9. Interference fit.
610 - 10. Letters are used within the part number. The letter H indicates an interference fit. The letter N indicates a clearance fit.

611 - 1. The straight portion of the pin.
611 - 2. To avoid sheet separation during installation.
611 - 3. The beaded area of the collar is near the surface of the material being fastened.
611 - 4. The end of the pin should be either flush or extend no more than TO allowances above the top of the collar.
611 - 5. The bead on the collar will be fully swaged through the complete length of the collar.
611 - 6. The sheet must be over 0.020 of an inch.
611 - 7. By installing temporary fasteners in every other hole prior to installation.
611 - 8. The MEK solvent would degrease the lockbolt pin, which would change the driving characteristics of the lockbolt.
611 - 9. When the surface is not perpendicular to the axis of the hole.
611 - 10. When the surface exceed 7° from a perpendicular with the axis of the hole.

612 - 1. Whether the lockbolts where installed in an aerodynamic or nonaerodynamic area of the aircraft.
612 - 2. Aluminum lockbolts.
612 - 3. 60 percent.
612 - 4. The diameter of the lockbolt and the amount of surface content.
612 - 5. The thickness of the thinnest sheet being fastened together.
612 - 6. When access is limited to the collar area.
612 - 7. The same as the diameter of the lockbolt.
612 - 8. When the lockbolt pin has been driven out of the hole.
612 - 9. When the material is thin or nonrigid.
612 - 10. 0.015 of an inch.

613 - 1. Rivet and bolt.
613 - 2. Areas requiring high tensile strength.
613 - 3. This permits an Allen wrench to be inserted, preventing the pin from turning during the installation of the locking collar.
613 - 4. Because of the collar break-off at a designed preload.
613 - 5. The letter W indicates that a washer is attached to the locking collar.
613 - 6. Aluminum (7075-T6), titanium alloys, and corrosion resistant steel.
613 - 7. A self-aligning collar-washer assembly.
613 - 8. Corrosion resistant steel.
613 - 9. Black.
613 - 10. High torque-off type steel collar.

614 - 1. The material thickness of the parts being fastened.
614 - 2. 0.625.
614 - 3. When the total thickness of both washers does not exceed 0.032 of an inch.
614 - 4. Corrosion resistant steel.
614 - 5. Four times the diameter of the Hi-Lok pin.
614 - 6. Interference fit.
614 - 7. The type Hi-Lok being installed - either tension or shear type.
614 - 8. The fatigue life of the Hi-Lok fastener is increased.
614 - 9. Pulling the head of a Hi-Lok pin into an interference fit hole by torquing on the collar.
614 - 10. The shank portion of the Hi-Lok pin is coated with sealant while lockbolt fastener *must* not have sealant on the shank portion of the pin to insure proper installation.

615 - 1. Surface contact, countersink fit, and flushness requirements.
615 - 2. Cracked or cut collars.
615 - 3. When the Hi-Lok fastener being removed has been installed in an interference fit hole.
615 - 4. So as not to damage the surrounding structures.
615 - 5. The amount of pin protrusion.

616 - 1. Threaded and unthreaded (swage type).
616 - 2. Light-weight low-profile styles.
616 - 3. Shear, shear/tension, or tension type head configuration.
616 - 4. The counterbore within the washernut assembly.
616 - 5. When surface slopes exceeds 2° but are not more than 6°.
616 - 6. If the diameter is too small, the bolt will spin freely in the hole making installation of the nut impossible. In contrast, if the diameter is too large, the threads will not come through the structure, again making it impossible to start the nut.
616 - 7. If the length is too long, the nut will not seat when the nut is fully tightened; if it is too short, the threads will not protrude sufficiently through the structure to permit starting the nut.
616 - 8. There is less force required and you are less apt to damage both the fastener and the surrounding structural members.
616 - 9. The washernut assembly eliminates washer-fumbling in hard to reach areas and does away with washers being dropped and lost in inaccessible or critical areas.
616 - 10. Taper-Loks offer the greater joint strength and are superior in clamping action.

617 - 1. Three groups.
617 - 2. The Taper-Lok groups and series, the material composition, and the diameter of the pin are the basic information indicated by the head markings.
617 - 3. The grip length is stamped on the bottom of the Taper-Lok pin.
617 - 4. The indented slots denote the direction of the injection ports on the shank of the Taper-Lok fastener.

617 - 5. This indicates the depth of the injection ports on the shank of the Taper-Lok fasteners. The number 10 would indicate that the depth is 0.100 of an inch. Each increment is measured in 0.010 of an inch.

618 - 1. Proper fit between the Taper-Lok fasteners and their holes.
618 - 2. The type, group number, and diameter of Taper-Lok are indicated by the numberimg code.
618 - 3. After the front two flutes breaks through the material.
618 - 4. The complete drill-reamer does the cutting.
618 - 5. The leading edge cutting tips do not cut while the taper drill is being removed plus, chip galling on backout is eliminated due to instant drill and chip relief.
a. Using a drill bushing fixture, pilot drill down in the shank of the Jo-Bolt until the bolt head separates.
b. Remove the remaining nut from the hole with a punch.
618 - 6. Within 0.030 of an inch as thick as the parts on the aircraft being fastened.
618 - 7. 2°.
618 - 8. To check the amount of surface bearing against the fasteners.
618 - 9. Cetyle alcohol.
618 - 10. Only finger pressure.

619 - 1. Letting the drill-reamer dwell in the hole could cause oversized holes.
619 - 2. A bright smooth finish.
619 - 3. If uncured faying surface sealant is present.
619 - 4. Use a plastic brush or cheesecloth dampened with MEK. When using cheesecloth insert it from the lower surface and pull the cloth completely through the hole.
619 - 5. A false torque value may result because of the sealant resistant.
619 - 6. They should be free of chips, longitudinal scratches rifling, and other imperfections.
619 - 7. It should be 1/64 of an inch smaller than the final hole size.

620 - 1. Distortion is evidenced by the appearance of a distinct ring on the head of the fastener.
620 - 2. 0.003 of an inch provided the gap doesn't exceed one-third the perimeter of the fastener head.
620 - 3. 0.004 of an inch provided the gap does not exceed one-half the perimeter of the fastener head.
620 - 4. 0.0015.
620 - 5. Pin protrusion.
620 - 6. If it wasn't damaged when removed and also if it can be relubricated.
620 - 7. Because of the tapered hole.
620 - 8. Because of the tapered hole.
620 - 9. When the pin-protrusion meets TO specifications.
620 - 10. Only when approved by a structured engineer.

621 - 1. An aluminum alloy or steel nut, a threaded alloy steel bolt, and a corrosion resistant steel sleeve.
621 - 2. Protruding (Hex) head, a 100° flush head, and a millable flush head.
621 - 3. The -8 indicates the diameter measured in 32nds of an inch. The -10 indicates the grip length measured in 16ths of an inch.

622 - 1. The thickness of part being fastened.
622 - 2. Protruding (Hex) head Jo-Bolts are measured from the bottom side of the manufactured head to the point on the shank where the taper on the end section starts. Countersunk head Jo-Belts are measured from the top of the manufactured head to the point on the shank where the taper on the end section starts.
622 - 3. Select the shorter grip length for installation.
622 - 4. They should be pilot drilled and then reamed to final hole size.

623 - 1. When installed flush head Jo-Bolts do not meet the smoothness requirements of the area where they are installed.
623 - 2. Jo-Bolts installed on nonaerodynamic surfaces shall be within 0.015 of an inch above and to 0.006 of an inch below the surface.
623 - 3. The diameter of the Jo-Bolt and whether sealant is being used.
623 - 4. For protruding head Jo-Bolts, the minimum spacing is three and one half times the diameter. For countersunk type Jo-Bolts, the minimum edge distance spacing is two times the diameter.

624 - 1. The removal procedures for nonrotating Jo-Bolts is as follows:
a. Pilot drill the head of the Jo-Bolt to the juncture of head and shank.
b. Redrill to the same depth, using a twist drill slightly smaller than diameter of the Jo-Bolt.
c. After drilling, take a punch, sever the head, and drive out the shank.
624 - 2. The removal procedures for rotating Jo-Bolts is as follows:
a. Using a drill bushing fixture, pilot drill down in the shank of the Jo-Bolt until the bolt head separates.
b. Remove the remaining nut from the hole with a punch.

625 - 1. A Hi-Shear threaded blind bolt consists of a ductile sleeve; a self-locking nut like expander; and a heat-treated, high strength core bolt.
625 - 2. Countersunk and protruding head styles.
625 - 3. Diameters are measured in 32nds of an inch and the grip length is measured in 16ths of an inch.

626 - 1. They should be pilot-drilled then reamed to size.
626 - 2. The tools needed to install Hi-Shear threaded blind bolts are:
a. Tool body assembly.
b. Crow foot wrench.
c. Torque wrench.
d. Socket or open-end wrench.
e. Phillip's screwdriver or Hi-Torque tipped driver.
626 - 3. *a.* The tool body assembly contains the mandrel and anvil for mounting the sleeve and expander prior to insertion into the work surface.
b. The crow foot wrench is used to turn the tool body which turns the expander up into the sleeve.
c. The torque wrench is attached to the crow foot wrench and indicates when the required installation torque is obtained.
d. The socket or open-end wrench is used to hold the chuck bolt portion of the tool body assembly from turning during installation. This prevents the sleeve from turning.
e. The Phillip's screwdriver or Hi-Torque driver are used to install the core bolt.

627 - 1. *a.* Yes.
b. Yes.
c. No.
627 - 2. 1. Remove core bolt.
2. Drill sleeve of bolt with a twist drill slightly smaller than the diameter.
3. Remove head of sleeve.
4. Punch out the sleeve and expander with a drift punch and hammer.

628 - 1. The shank portion of a mechanical-lock blind bolt consists of a long cylindrical sleeve, the locking collar, and a conical recess area.
628 - 2. The pin of a mechanical-lock blind bolt consists of three sections. The pulling section which has gripping grooves and extends above the head of the bolt, a locking groove which receives the locking collar, and a blind end section which forms the shop head.
628 - 3. *c* and *e*.

629 - 1. Consult the specific -3 TO for guidelines.
629 - 2. They should be pilot drilled then reamed to final size.
629 - 3. Change pulling guns and select a nose adapter for a 1/4 of an inch, protruding head blind bolt.
629 - 4. The pin is pulled into the shank forming the shop head. And after the shop head is formed, the inner anvil of the nose adapter forces the locking collar into the locking recess on the head of the shank. After the locking collar is locked in place, the pin is broken off at the breakneck groove.

630 - 1. The fit of the manufactured head against the work surface, the position of the locking collar, and the position of the pin.
630 - 2. *a.* Drill motor capable of 1250 rpms.
b. One twist drill.
c. Drill bushing fixture.
d. Two punches—a pin punch and a sleeve punch.
e. An adjustable micro-limit cutter.
630 - 3. *a.* The drill motor is needed for drilling.
b. The twist drill is used to drill out portions of the pin.
c. The drill bushing fixture is necessary to maintain proper twist drill alignment.
d. The pin punch is used to punch out the remaining pin section. The sleeve punch is used to punch out the remaining portion of the sleeve after counterboring.
e. The micro-limit cutter is used to grind away a portion of the top section of the sleeve.

CHAPTER 3

631 - 1. L.
631 - 2. H.
631 - 3. H.
631 - 4. L.
631 - 5. L.
631 - 6. H.
631 - 7. H.
631 - 8. H.
631 - 9. L.
631 - 10. L.

632 - 1. 9/32 of an inch.
632 - 2. 7/16 of an inch.
632 - 3. 13/32 of an inch.
632 - 4. By drilling out the attachment rivets.
632 - 5. Using a chisel or similar cutting tools.

633 - 1. To form a recess for swaging the cup to the panel.
633 - 2. After the cup is swaged in place.
633 - 3. To retain the stud and spring in the cup.

634 - 1. Grommet.
634 - 2. Receptacle.
634 - 3. Receptacle.
634 - 4. Stud assembly.
634 - 5. Grommet.
634 - 6. Receptacle.
634 - 7. Stud assembly.
634 - 8. Grommet.

635 - 1. Grommet.
635 - 2. Grommet.
635 - 3. Stud assembly.
635 - 4. Receptacle.
635 - 5. Stud assembly.
635 - 6. Grommet.

636 - 1. Number 5.
636 - 2. By checking the head markings on the stud.
636 - 3. Receptacles.
636 - 4. Whether they are rigid or floating.
636 - 5. Cross-pin.

637 - 1. E.
637 - 2. F.
637 - 3. H.
637 - 4. B.
637 - 5. G.
637 - 6. C.
637 - 7. A.
637 - 8. D.

638 - 1. F.
638 - 2. T.
638 - 3. T.
638 - 4. F.
638 - 5. F.
638 - 6. T.
638 - 7. T.
638 - 8. T.
638 - 9. F.
638 - 10. T.

639 - 1. The sleeve bolt, retaining ring, and receptacle.
639 - 2. Allen wrench.
639 - 3. The one that has eight notches.
639 - 4. They are used as a housing for the retaining ring.
639 - 5. They are color coded.

640 - 1. The grip length is stamped at the bottom of the hex-shaped recess on the head of Deutsch Zip-Loc fasteners.
640 - 2. The Deutsch Zip-Loc retaining ring has flat inside surface areas and is slightly open at the ends whereas the Milson fastener's retaining ring has curved inside surface areas and the ends are butted together.
640 - 3. The serrations on the bottom of the Deutsch Zip-Loc stud.

641 - 1. A low speed drill motor and a counterbore cutter having a pilot-guide slightly smaller than the stud hole.
641 - 2. Install the stud and retaining ring; position the retaining plate on the stud; and lastly, lock a space receptacle in place. Then, drill the holes for the rivets.
641 - 3. Only after the holes for the retaining plate are countersunk.
641 - 4. When the stud has been removed.
641 - 5. Apply epoxy primer to surfaces of the stud which will contact the magnesium structures.

642 - 1. Dimpled type.
642 - 2. Shims.
642 - 3. 30 to 35 inch-pounds.

CHAPTER 4

643 - 1. T.
643 - 2. F.
643 - 3. F.
643 - 4. T.
643 - 5. T.
643 - 6. F.
643 - 7. F.
643 - 8. F.
643 - 9. T.
643 - 10. F.

644 - 1. Close tolerance bolt.
644 - 2. Internal wrenching bolt.
644 - 3. General purpose bolt.
644 - 4. Self-locking bolt.
644 - 5. Internal wrenching bolt.
644 - 6. Hi-Torque bolt.
644 - 7. Internal wrenching bolt.

645 - 1. 12 or 14-ounce hammer is required to move the bolt.
645 - 2. 1/32 of an inch undersize.
645 - 3. Check with an engineering officer.
645 - 4. ¼ of an inch diameter.
645 - 5. Steel washer.

646 - 1. Structural.
646 - 2. Self-tapping.
646 - 3. Machine.
646 - 4. Structural.
646 - 5. Structural.
646 - 6. Structural.
646 - 7. Structural.
646 - 8. Machine.
646 - 9. Self-tapping.
646 - 10. Self-tapping.

647 - 1. The purpose of any nut is to properly load the bolted assembly.
647 - 2. Tighten the bolt beyond the working load.
647 - 3. Tighten bolted assemblies beyond their working loads and keep them tight.
647 - 4. Insufficient tightening and lack of proper preload or clamping force.
647 - 5. Torsion and tension.
647 - 6. 10 percent.
647 - 7. A tough non-heat-treated nut is plastic enough to allow the threads to slightly deform upon tightening and adjust to distribute the load over all threads rather than just the first few. A heat-treaded nut cannot do this.

648 - 1. Two threads.
648 - 2. A bolted assembly should fail through separation of the shank, not through thread stripping.
648 - 3. Thickness of the nut.
648 - 4. They provide easier mating of the bolt threads with the threads in the nut.
648 - 5. Metal and nonmetallic insert types, ranging in size from 3/8 of an inch and smaller.
648 - 6. Using the nut in temperatures exceeding 450° F.
648 - 7. Use a nut that is silver plated.
648 - 8. Anodzing.
648 - 9. To prevent seizing and galling of threads.
648 - 10. Cadmium plating.

649 - 1. *a.* R.
649 - 1. *b.* 5.
649 - 1. *c.* 310.
649 - 1. *d.* DD.
649 - 1. *e.* AN.
649 - 2. *a.* B.
649 - 2. *b.* 350.
649 - 2. *c.* 10.
649 - 2. *d.* 32.
649 - 2. *e.* AN.

650 - 1. *e.*
650 - 2. *f.*
650 - 3. *c.*
650 - 4. *d, e.*
650 - 5. *d.*
650 - 6. *a, b.*
650 - 7. *a.*
650 - 8. *b.*
650 - 9. *d.*
650 - 10. *f.*

651 - 1. Castle nut.
651 - 2. Wing nut.
651 - 3. Plain check nut.
651 - 4. Light hexnut.
651 - 5. Plain hexnut.
651 - 6. Castellated shear nut.

652 - 1. 1, 2, 5, 7, 10, 12.
652 - 2. 3, 4, 6, 8, 9, 11.

653 - 1. *a* - F.
653 - 1. *b* - T.
653 - 1. *c* - F.
653 - 1. *d* - T.
653 - 1. *e* - F.
653 - 1. *f* - T.
653 - 1. *g* - F.
653 - 1. *h* - T.
653 - 1. *i* - F.
653 - 1. *j* - T.
653 - 2. *a* - Box-end wrenches should be used.
653 - 2. *c* - The nut must be replaced.
653 - 2. *e* - Cut bolts can be used if all burrs are removed.
653 - 2. *g* - Elastic stop nuts can be used up to temperature of 250° F.
653 - 2. *i* - The number 12, indicates temperature limitation.

654 - 1. Plain washer.
654 - 2. Countersunk washers.
654 - 3. High tensile washer.
654 - 4. Torque measurement on a previously installed preload indicating washer cannot be performed.
654 - 5. By installing the washer with wet primer.

655 - 1. An attachment plate from a broken latch can be used as a template.
655 - 2. The thickness of the access panel or door and the combined thickness of the access panel or door and retaining ring.
655 - 3. An oversized latch was installed.
655 - 4. It will not fasten.
655 - 5. The attachment plate can be used as a template because the holes are predrilled.

656 - 1. Formed.
656 - 2. Extruded.
656 - 3. Formed.
656 - 4. Extruded.
656 - 5. Extruded.

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SUPPLEMENTARY MATERIAL

CDC 53153

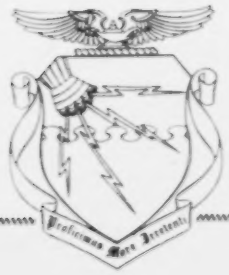
AIRFRAME REPAIR SPECIALIST

(AFSC 42755)

Volume 4

IMPORTANT: Make the corrections indicated in this supplement before beginning study of this volume. This supplement contains both "pen-and-ink" changes and page insertions. It is perforated and three-hole-punched so that you can insert the additional pages.

NOTE: This supplement is valued at 3 hours (1 point).



Extension Course Institute
Air University

CHANGES FOR THE TEXT:

Pen-and-Ink Changes:

Page-Col	*Subject*	*Line(s)*	*Correction*
Cover			Change "(AFSC 53153)" to "(AFSC 47255)."
1R		6	Change "play" to "plug."
5R		13	Change "prepared hole" to "gun."
5	Table 1-1		Change "FRICTION" under top chart to "MECHANICAL" and change "MECHANICAL" under bottom chart to "FRICTION."
9R		6	Change "two" to "three."
9R		13	Change "test" to "text."
10R		4, 5 fr bot	Delete sentence "Briefly refer to figure 1-9 and notice the system used for the Cherrylock rivet."
14R		3	Delete the entire line.
14R		8	Change "this" to "thin."
14R	604-5	3	Change "this" to "thin."
15L		18	Change last word in line "hand" to "head."
			Following "head" insert the following: "Excessive grip length is indicated by the stem's breaking off well above the manufactured head."
22R		5 fr bot	Insert the word "used" between "not" and "under."
36R		3	Change "HL180812" to "HL 1870-8-12."
40R		13, 14	Delete "sealant contained" and replace with "containment of sealant within."
48L	*Example*	18 fr bot	Insert an en dash between "1" and "4" so that it reads "1–4."
48L		Last line	Insert "–4" at far left in front of "– Pin diameter in sixteenths of an inch."
50R	618-8	1	Change "wht" to "what."
56R		8	Change "1/26/" to "1/16."
59R		1	Change "clockwise" to "counterclockwise."
67L		3	Change "structual" to "structural."
78R		5	Change "shut" to "sheet."
94R		22	Change "etaining" to "retaining."
103L		4 fr bot	Change "may be" to "is."
108L		20 fr bot	Change resuls" to "results."
114R		5	Change "Howeer" to "However."
120L		1	Change "formal" to "formed."

Changes for Answers for Exercises:

123R	606-5	1	Change "of" to "or."
125L	620-10		Change "structured" to "structural."

Page Additions:

Insert the following additional pages:

120a–120o
128

4-3. Working Practices Related to Removable Fasteners

By now you can easily see that today's aircraft fasteners are not your local hardware or discount store type. They cost money and lots of it. It is estimated that between 15 to 20 percent of the initial cost of today's aircraft, such as the F-15, goes towards the cost of fasteners alone. This cost is especially high when it comes to the removal types such as bolts, screws, and turnlock fasteners, because these are normally priced individually, not by the pound as are solid rivets. So it only stands to reason that every effort should be taken to keep the cost of replacing these costly fasteners down to a minimum when performing maintenance. So how do you do this? You do this by following work procedures that will keep from damaging these fasteners whenever they are removed and reinstalled.

In this section, we will look at the working practices related to the removal and installation of fasteners, especially the countersunk structural screws on external access panels. What we will do is trace the step-by-step sequence used when removing and replacing an access panel, while at the same time stressing the major points to remember to prevent fastener damage.

657. Differentiate between the various types of internal wrenching fastener recesses and indicate how specific characteristic features of fasteners used in access panels are identified and influence removal tool selection.

Once the job of removing and replacing an access panel was a simple task, but with the introduction of newer aircraft with advanced construction techniques and materials, the days of the "two-fisted screwdriver maintenance specialist" are over. This once simple job has evolved into a task that challenges even the "old pros" of the maintenance game.

Years ago without even seeing the panel, you could select the proper removal tools—the common and crosspoint screwdrivers. But this is not the case today. Not only must you see the panel; you must now closely examine its fasteners so as to determine their internal wrenching recess designs, head style, and shank diameter. Each of these factors directly influences the type and size of removal tools required. This is your first step in panel removal—removal tool determination.

Internal Wrenching Recess Designs. Figure 4-27 shows the variety of internal wrenching recesses you are faced with on today's aircraft. Some or all of these recesses will be found on just about all the categories of fasteners. Proper identification of these recesses is the foundation of panel removal. Let's briefly look at the unique characteristics which separate each from one another.

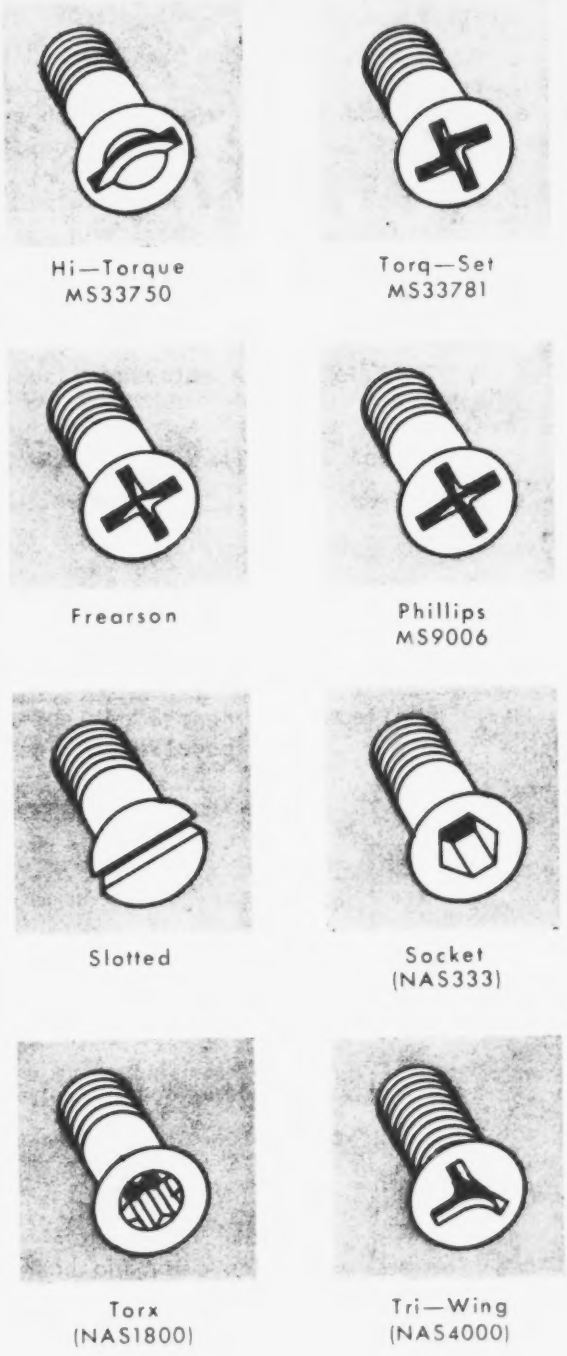


Figure 4-27. Types of internal wrenching fastener recesses.

Phillips recess. The Phillips recess has four driving wings with the corners of the recess at the head surface being slightly cambered. The slot tapers to a blunt bottom.

Frearson (Reed & Prince) recess. At first glance, the Frearson (Reed & Prince) recess appears to be very similar to the Phillips recess. However, a closer look reveals that the corners are a square cut design at the head surface and the slot tapers to a sharp bottom instead of a blunt one as in the Phillips.

Torq-set recess. The torque-set recess is easily identified when compared to the Phillips and Frearson (Reed & Prince) recesses. Its driving wings are offset with straight sides while the ends of the slot taper to a blunt bottom. The installation sides of the slots are somewhat shorter than the removal sides. This is because the torque requirements for removal are usually higher than installation torque requirements. The extra length provides a larger bearing surface for the driver bit during removal.

Tri-wing recess. The tri-wing recess is distinct because of its three driving wings. The sides of the slots are similar to the torque-set recess because the installation and removal sides are different lengths. The slots themselves taper to a blunt bottom.

Slotted recess. The slotted recess, or sometimes referred to as a common recess, is the most universally used recess and is distinctive because of its single flat-bottomed slot.

Hi-torque recess. The hi-torque recess, like the slotted recess, has a single slot but this is where the similarity ends. The hi-torque slot has a curved bottom, narrower at the center than at the ends. This curved bottom and the center dimple make it readily identifiable by its "bow tie" appearance. The sides of the slot are undercut, producing an inverted keystone shape in the cross-section. This keystone shape is what "locks" the removal tool in place.

Socket recess. The socket recess, better known as an Allen head recess, has a six-sided recess with corners made in a square cut design.

Torx recess. The torx recess is the final type of recess we'll examine. At first glance, it looks somewhat like the socket recess. However, close inspection reveals a star-shaped design having six short driving wings with rounded corners, similar to a six-tooth gear or sprocket. The sides of the recess are straight.

Head Styles. Once you have identified the recess design, your next step is to determine the head style of the fasteners. They can either have a standard or reduced countersunk head style. The style of head will influence your selection of removal and installation tools.

The standard, or tension head, is the most widely used because of its large diameter head or bearing surface. It is used where tensile stress is of prime concern. Tensile stress is the force exerted by the panel trying to pull out away from the aircraft.

The reduced head has a smaller bearing surface. It is sometimes called a shear head because it is used in thinner panels where side motion or stresses are the primary concern. A reduced head fastener will require a larger size removal tool, even though it has the same shank diameter as a fastener with a standard head style. Figure 4-28 shows a comparison of both head styles. As you increase your knowledge through experience, you should be able quickly to distinguish between them.

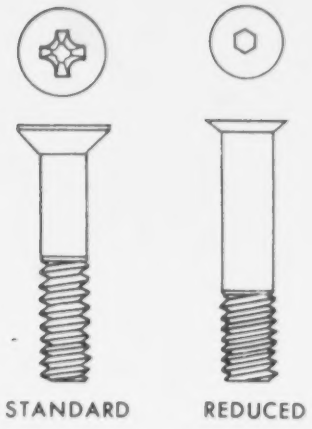


Figure 4-28. Standard and reduced head styles.

Shank Diameter. The last item you need to know before selecting the required removal tools is the shank diameter. This is done in a number of ways. First, there are the identifying symbols and number codings on the head of the fastener. The fastener's shank diameter will be shown as the last digit of the National Aircraft Standard or NAS class code. For example, an NAS class code of NAS585 indicates a shank diameter of 5/16th of an inch. If the last digit had been a 4, then it would be 1/4 of an inch in diameter. Note the first dash number will indicate the specific grip length (NAS585-6). The other way is by visual comparison. This you will acquire as you increase your experience and knowledge about fasteners. There will be times when both of these two ways won't be necessary because the panel you are removing will have a fastener location decal on it. This decal will indicate the specific location of each fastener in the panel in terms of shank diameter and grip length.

With the information you have obtained about the panels recess design, head style, and shank diameter, you can correctly select your removal tools.

Exercises (657):

1. In the space provided, name the type of internal wrenching fastener the statement identifies:

_____ a. Slots taper to a sharp point.
_____ b. Driving wings are off-set.
_____ c. Bottom of recess is curved.
_____ d. Most often used type of recess.
_____ e. Has six driving wings with rounded corners.

_____ f. Slots between its three driving wings taper to a blunt bottom.
_____ g. Has different sizes of driving wings—four long, four short.
_____ h. Corners of the recess are slightly cambered.
_____ i. Has six driving wings with square corners.
_____ j. Has a "bow tie" appearance.

2. How does a standard countersunk head style differ from a nonstandard countersunk head style?

3. How is it possible to identify the specific diameter and grip length of an installed fastener in an access panel?

4. Why is it necessary to properly identify the specific head style of an installed fastener?

5. Why is it necessary to know the correct shank diameter of an installed fastener?

658. Cite factors related to the procedures employed when selecting or using removal tools associated with fasteners having internal wrenching recesses.

Once you have determined the correct type of recess, head style, and shank diameter of the panel's fasteners, your next step is to select the correct type and size driver tools. (The word "driver" indicates installation and removal tool.) This tool selection step is extremely important in that a mistake now can cause recess damage, delaying the removal of the panel and thus resulting in wasted man-hours and materials. To avoid making this mistake, you should quickly become familiar with the various tool designs available and be able to select the specific driver tool for each type of recess.

Driver Tool Design. The screwdriver and driver bit (sometimes referred to simply as an apex) are the two basic styles of driver tools available. The driver bit is manufactured in two types. One connects directly onto the end of a speed handle or ratchet assembly set-up, while the other type must be inserted into a nose adapter. This nose adapter is then attached to a speed handle or ratchet assembly. The particular style or combination of driver tool set-up depends on a number of factors. Factors such as how many fasteners are being removed, the shank diameter of the fasteners, the amount of installation or removal torque required, and the space (clearance) you have to work in, are just a few of the many things you will have to consider before selecting the needed tools.

Specific Driver Tool Selection. Each of the different recesses mentioned earlier requires a different type of driver tool. This might seem like a foolish statement because anyone can see and surely understand that different recesses call for different driver tools. But, look at figure 4-29 for a minute. Do these damaged recesses reflect the foolishness of the opening statement? Are these damages the results of improper tool selection and usage, or the failure to follow proper removal or installation procedures, or is it the result of

Damaged Hi—Torque Recess (Do Not Use)
Damaged Torq—Set Recess (Do Not Use)
Damaged Frearson Recess (Do Not Use)
Damaged Phillips Recess (Do Not Use)
Damaged Slotted Recess (Do Not Use)
Damaged Socket Recess (Do Not Use)
Damaged Torx Recess (Do Not Use)
Damaged Tri—Wing Recess (Do Not Use)

Figure 4-29. Damaged internal wrenching fastener recesses.

using properly selected driver tools which are unserviceable? Whatever the case may be, this won't happen to you if you adhere to the following information. For the purpose of our discussion, only the Phillips, Frearson, torq-set, and hi-torque driver tools will be covered, since these are the ones you will work with most often.

Phillips versus Frearson (Reed & Prince). The screwdriver or driver bit used to install Phillips-type recess fasteners has four driving wings which taper to a BLUNT point. However, the Frearson (Reed & Prince) also has four driving wings, but here is the all important difference: they taper to a SHARP point. Whenever a Frearson (Reed & Prince) driver tool is used in Phillips-type recess, the fit is such that when torque is applied, the misalignment of the tapered angles on the driver tool quickly shears out the inside of the Phillips recess, completely destroying it. The same situation in reverse (Phillips driver tool in a Frearson recess) will cause the same results. Because of this, it is extremely important that you properly distinguish between these two recesses and driver tools.

The driver tools used for either the Phillips or Frearson (Reed & Prince) have an identifying number code based on the shank diameter/diameters of the fasteners they can be used to remove. Figure 4-30 indicates the driver/recess selection guidelines pertaining to the Phillips-type recess fasteners.

Torq-set driver tools. Driver tools for torq-set recess fasteners are easily identified from the Phillips and Frearson driver tools by the "off-centered" arrangement of their four driving wings. By looking directly down at the driving wings, this "off-centered" placement becomes quickly apparent. This is the best method to identify torq-set driver tools. If you were to look quickly at a torq-set driver tool from the side, it could easily be mistaken for a Phillips driver tool because of its blunt point.

Like the Phillips and Frearson driver tools, the torq-set driver tools are number coded to reflect a specific fastener shank diameter they are used for. Figure 4-31 indicates the driver tool selection guidelines. Notice in the third column, the effect that occurs to the driver tool selection when the panel's fasteners have reduced head style. A one size smaller driver bit is required.

Hi-torque driver tools. The hi-torque driver tools you will use are either the wheel driver assembly or the solid blade head (socket) driver, as shown in figure 4-32. Both these tools are used in conjunction with a speed handle or ratchet assembly set-up. The circular driver blade of the wheel driver assembly and the edge blade of the solid head driver are individually designed in thickness and radius to correspond to a specific shank diameter fastener. Figure 4-33 shows the specific driver tool for each specific diameter fastener based on head style. Both blade drivers have a small edge lip, like the lip on a nickel, which interlocks with the walls of the recess.

It is this interlocking design feature that requires that the driver tool be "rolled" into the recess from one

Nominal Fastener Size	Driver/Recess Number
# 8	2
# 10	2
1/4	3
5/16	4
3/8	4
7/16	4
1/2	4
9/16	4

Figure 4-30. Phillips driver selection factors.

Nominal Fastener Size	100° Flush and Protruding Head Recess and Driver Size	100° Reduced Flush Head Recess and Driver Size
# 0	0	—
# 1	1	—
# 2	2	—
# 3	3	—
# 4	4	—
# 5	5	—
# 6	6	—
# 8	8	6
# 10	10	8
1/4	1/4	10
5/16	5/16	1/4
3/8	3/8	5/16
7/16	7/16	3/8
1/2	1/2	7/16
9/16	9/16	1/2
5/8	5/8	9/16

Figure 4-31. Torq-set driver selection factors.

end so that it will fit properly into the curved bottom of the recess. If you push the driver tool directly into the recess, this will destroy the interlocking ability of the recess, resulting in the lowering of the torque-resistant factor of the recess. In other words, the driver tool will slip out of the recess at a lower applied torque, resulting in a damaged recess or surrounding skin area.

NOTE: The use of a common screwdriver tool in a hi-torq recess will quickly destroy the out ends of the recess. The curved bottom of the hi-torq recess makes the use of a common screwdriver impossible.

The wheel driver assembly has an advantage in that the circular driver blade can be rotated when one portion of the blade becomes worn or damaged, as shown in figure 4-34, or it can be replaced when it is completely worn or chipped. On the other hand, when the solid blade driver is worn or chipped as seen in figure 4-35, it must be replaced.

Exercises (658):

1. What additional factors besides recess design influence the types of driver tool set-up you will use?

2. If you were handed two screwdrivers, one a Phillips, the other a Frearson, how can you tell the difference between them?

3. What is the surest way to identify a torq-set driver tool from either a Phillips or Frearson driver tool?

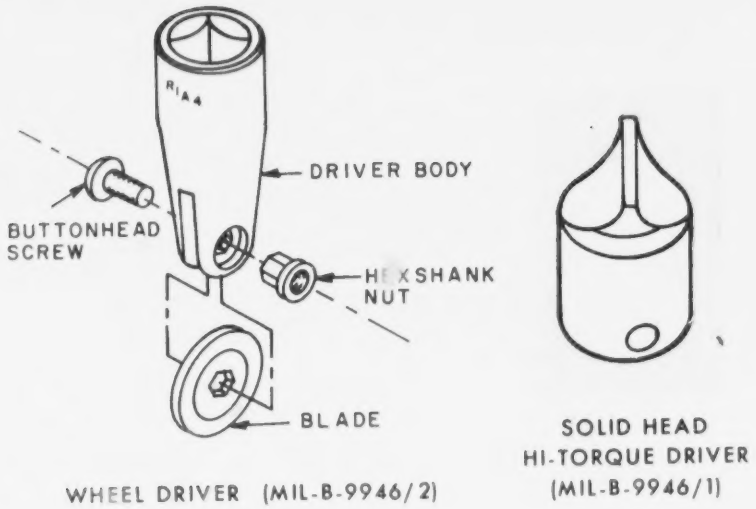


Figure 4-32. Hi-torq driver tools.

Nominal Fastener Size	100° Flush and Protruding Head		100° Reduced Head	
	MIL-B-9946/1 Solid Driver	MIL-B-9946/2 Wheel Driver	MIL-B-9946/1 Solid Driver	MIL-B-9946/2 Wheel Driver
#4	HTS-1	---	---	---
#6	HTS-1	---	---	---
#8	HTS-2*	HTA2*	---	---
#10 (3/16)	HTS-3*	HTA3*	HTS-2*	HTA2*
1/4	HTS-4	HTA4	HTS-3*	HTA3*
5/16	HTS-5	HTA5	HTS-4	HTA4
3/8	HTS-6	HTA6	HTS-5	HTA5
7/16	HTS-7	---	HTS-6	HTA6
1/2	HTS-8	---	HTS-7	---
9/16	HTS-9	---	HTS-8	---
5/8	HTS-10	---	HTS-9	---

* The tip thickness of the -2 and -3 drivers is the same but the tip diameter is different. Do not interchange!

Figure 4-33. Hi-torq driver selection factors.

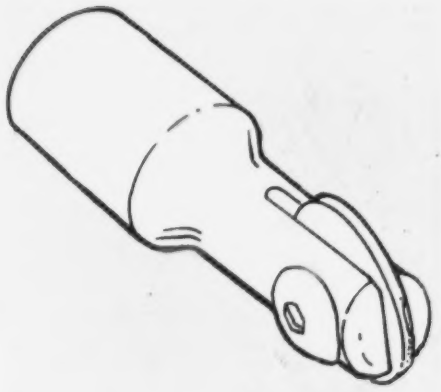


Figure 4-34. Damaged hi-torq wheel driver.

4. Why is it necessary to "roll" the driver tool into a hi-torque recess?

5. Why is it impossible to use a common screwdriver in a hi-torque recess?

6. What advantage has a circular wheel blade driver have over a solid blade driver used for hi-torque recesses?

659. State why specific work procedures are employed during the removal and reinstallation of an access panel having internal wrenching recess fasteners.

Having selected the correct driver tools, it's now time to start removing the access panel. Just by having the right driver tools is no sure guarantee that you won't have some problems. But if you couple the facts—you have the right tools with time-tested and proven working practices—you will have few problems, if any. The complete operation, from removal to reinstallation, can be broken down in four separate action phases—preparation, removal, off-inspection, and reinstallation. Each of these separate phases is interdependent upon each other, and how well you accomplish one phase will directly effect the results of another phase. Before looking at these phases separately, there is one preaction phase that needs emphasizing—the safety phase.

Safety Phase. As for any maintenance operation, you should make sure that you are not the cause of damage or become "an accident looking for a place to happen." If the access panel you are removing is located near honeycomb or fiberglass assemblies or any other similar type of "facile" structures, you must take special efforts to protect these areas from either being stepped on or damaged if a tool should be dropped. Secondly, if the access panel is above ground-level reach, make sure that any maintenance stands, platforms, or whatever you are using, are locked in place and that all safety items related to their use are being used. Once these two items have been taken care of, you are now ready to remove the panel in an effective and safe manner.

Preparation Phase. Within this phase, you start to prepare the fasteners for removal and at the same time, inspect each recess and mark the different grip length locations. You prepare the fastener by cleaning out the internal wrench recess. Using your scribe, remove all foreign materials including paint from each fastener's recess. Be extra careful during the clean out not to slip with the scribe, scratching or gouging the surrounding skin surfaces. This clean out is necessary so that the driver bit will fully set itself when inserted into the recess, thereby preventing the possible slippage of the driver bit from the recess before the needed removal torque is reached.

While you are cleaning out the recesses, also inspect and mark those recesses that show signs of recess damage or excessive wear. These must be replaced before the panel is reinstalled. These damaged recesses could also indicate that something is wrong with the internal locking mechanism and should be inspected when the panel is off.

The last part of the preparation phase involves marking, with a grease pencil either on the panel itself or on the surrounding skin surface, the locations of the different fastener grip lengths for panels that do not have a fastener decal indicating this information. In situations where a fairly large panel is being removed, a fastener location template should be used into which each fastener is placed as it is removed. The placement of the fasteners in the template will correspond to their exact location in the access panel. Your main concern in marking grip length locations or using fastener location templates is to insure that the same length fastener is placed back into its original hole location. If too short a fastener is placed where a longer fastener is

Figure 4-35. Damaged solid head hi-torq driver.

called for, it will be just a matter of time before it works itself loose and falls out. And if this panel is located forward of an intake, this could spell disaster. On the other hand, too long a fastener also causes problems. Internal locking devices such as nut plates and channel nut assemblies are broken. When this occurs, the fastener more often than not will have to be drilled out. The extra time it takes to mark or use grip length fastener location template will pay off when it comes to reinstalling the panel.

Removal Phase. The proper execution of this phase depends on three factors—tool alignment, end-load pressure, and torque application. Each factor is dependent upon each other. Too much or not enough of any one of these factors will result in removal problems. A proper balance must be maintained between these factors to effectively remove the fasteners.

Tool alignment. This involves two aspects—alignment of the tools themselves and alignment of the tools to the fastener being removed. The first alignment called for relates to the tool set-up you are using. Does the speed handle and nose adapter or socket fit properly? Is there excessive "wobble" (lateral movement)? Your tool set-up must be free of wobble to prevent slippage of the driver, especially when a circular driver blade is being used. The other alignment requirement is insertion of the driver bit into the recess. The driver bit must be held "in-line" 90° with the head of the fastener at all times during anytime torque is being applied. This alignment insures the proper transfer of torque pressures from the driving wings of the driver bit to the contacting surfaces within the fastener recess. If the alignment is off-centered, excessive pressure is applied only to part of the recess contacting surfaces, which usually results in damage to the recess when torque is applied.

End-load pressure. This refers to the amount of inward (downward) pressure applied to the driver tool. This end-load pressure is needed to keep the driver bit fully inserted in the recess when torque is being applied so that "cam-out" (recess damage) won't occur. Once the fastener is broken loose,the amount of the end-load pressure must be reduced, maintaining just enough pressure to keep the driver bit inside the recess. If you don't reduce the initial end-load pressure as the fastener is being removed, the excessive amount of end-load pressure will cause separation of the internal locking devices (nut plates, channel nut, etc.), and in cases where the locking devices have been bonded in place, total disbonding will occur. Under these situations, the fastener will again have to be drilled out.

Torque application. The last factor, torque application, deals with how it is applied. Torque should be applied in a smooth, uniform manner. You should not "SNAP LOAD" torque. In most cases if you snap load torque, the rapid loading will quickly overcome your end-load pressure, causing the driver bit to slip out of the recess. If this doesn't occur, then either the driving wings of the driver bit or the contacting surfaces in the recess will be damaged.

As each fastener is loosened, you can either remove it completely or leave it halfway out and then start removing another fastener. If you are working by yourself, leaving the fasteners halfway out until they all are loose is recommended. In this way, the chances of misplacing the removed fasteners are reduced by removing them all in one step. At no time should removed fasteners be placed on the ground or on the surface of the aircraft where they might be stepped on. They must be placed in a suitable container, such as a cloth bag, and kept with the removed panel.

NOTE: Make sure proper documentation is entered in the aircraft's forms indicating a panel has been removed with the required maintenance symbol.

Off-Inspection Phase. This phase involves inspecting the internal locking devices for broken nut plates, channel nuts, loose rivets, etc. Inspect especially those areas indicated during the recess clean-out step. If no damage is found, then this phase is over, but if damage is found, it should be taken care of immediately rather than wait until the panel is to be reinstalled.

Reinstallation Phase. If you have followed the working procedures outlined in the first three action phases, then this last one should present you with no problems. Some of the "key" points to remember at this time are:

That contracting surfaces between the access panel and aircraft are clean of foreign materials before the panel is placed in position.

That fasteners are installed in a three-step operation:

Step 1—all fasteners are hand started—this insures proper mating of threads.

Step 2—all fasteners are tightened initially down until the heads contact the skin surface using minimum end load pressure.

Step 3—final torques are applied with some type of torque indicating tool.

That all aircraft fasteners have a specific torque requirement that must be maintained. Figure 4-36 shows the torque requirements based on the shank diameter and style of head design. Always consult the specific dash 3 TO for the applicable aircraft you are working on.

That any additional clockwise movement after the required torque is obtained can increase the torque required for removal beyond normal requirement, which may be beyond the material capability of the fastener's recess, resulting cam-out.

Exercises (659):

1. Why is it required to include a safety phase in any maintenance operation you perform?

Nominal Size (Inch)	Torque (Inch-Pounds)	
	100° Flush and Protruding Head	100° Reduced Head
3/16	30 - 40	20 - 25
1/4	80 - 100	30 - 40
5/16	160 - 200	80 - 100
3/8	220 - 270	160 - 200
7/16	440 - 550	220 - 270
1/2	680 - 850	450 - 550
9/16	960 - 1200	680 - 850
5/8	1300 - 1620	960 - 1200

Figure 4-36. Recommended torque requirements.

2. Why is it necessary to clean out the internal wrenching recesses before applying any torque?

3. What purpose is served by marking the location of different fastener grip lengths?

4. Why is it necessary to insure that the amount of lateral movement is kept to a minimum in your tool removal setup?

5. Why is it required to reduce the amount of end-load pressure once the fastener is loosened?

6. Why must torque, be it removal or installation, be applied in a steady, even manner?

7. Why is it recommended that when replacing fasteners they be finger started?

8. Why is it necessary to insure that only the required amount of installation torque is applied?

9. What is meant by the term "in line" as it relates to the tools used for removing or reinstalling fasteners?

10. When removing fasteners by yourself, why is it recommended that you leave each fastener halfway out until all fasteners are loosened?

4-4. Working Practices Related to Screw Removal

Occasionally, it will be impossible to remove a screw using normal removal tools or practices. This problem occurs when it is impossible to apply adequate end load and/or torque because the recess is damaged or the screw's threads are either corroded or covered with sealant. When these conditions occur, impact drivers, fastener removal tools, or fastener extractors have to be used.

It must be noted that while this area of maintenance is the responsibility of the machinist specialist, there will be times when you will be called upon to remove broken or stripped out screws. So it is to your advantage to know the correct procedures and tools

required, rather than be the cause of any additional damage. With this in mind, let's look at some of the different procedures available.

660. Cite specific procedures and precautions to observe when using impact tools to remove screws.

One of the standard ways of loosening corroded or overtorqued screws is to use impact tools. The two methods used are the pneumatic hammer type and the hand-operated type. Certain factors, such as how many screws are being removed, the availability of compressed air, and the space you are working in, will dictate which of the methods you use.

Using the Pneumatic Hammer. To use the pneumatic hammer when removing screws, you must have an adapter that will fit into the hammer receptacle and will hold a driver bit. A typical adapter is shown in figure 4-37. You can make an adapter from an old rivet set by grinding a square drive on the end of it. The rivet set already has the correct shape on the hammer receptacle end and is already hardened.

The most important thing to check before using the pneumatic hammer to remove screws is the amount and type of backing behind the surface containing the screws. If the surface is not solidly supported by internal bracing members, then the pneumatic hammer should *not* be used. In areas that are not supported properly, the pneumatic hammer can drive the screw right through the skin or severely dent the area around the screw.

Once you have determined that the internal support is sufficient to use the hammer, you should adjust the air pressure so that the hammer does not strike the adapter with excessive force. It isn't the force of the blows that breaks the screw loose so much as it is the rapid vibration which tends to break up corrosion or sealant between the screw and parent threads. The screw should not be rotated more than a quarter of a turn with the pneumatic hammer. If you turn it too far, the hammer blows can damage the threads in the parent part (usually a nut plate), which can easily be knocked loose. After the screw has been loosened, remove it using a screwdriver or speed handle.

The pneumatic hammer can be used effectively to remove screws even though the recesses are nearly stripped completely out. By maintaining a steady pressure on the tool and using a light turning pressure on the adapter, the striking of the hammer will

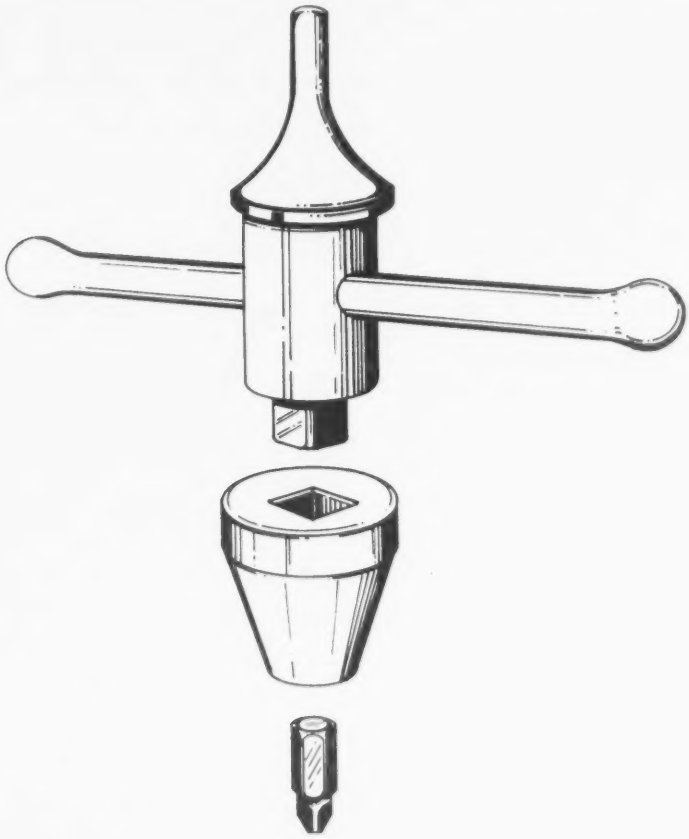


Figure 4-37. Driver bit adapter tool for pneumatic hammer.

normally reform the recess sufficiently to allow the screw to be loosened. You should always wear safety glasses with the pneumatic hammer. The driver bits have been known to break easily. Also, be sure that the driver bit is solidly in place within the screw's recess before you are hammering; otherwise, the driver could bounce off the screw and damage the surrounding surface or cause injury to you.

Using the Hand-Held Impact Driver. The main difference between this method and the pneumatic hammer method is in the way the hammering force is applied. In the hand-held method, you have somewhat more control of this hammering force. The procedures for the hand-held method are fundamentally the same as for the pneumatic method with the added precaution of insuring that you strike the impact tool, not your hand, with the hammer. You would select this mehod when only a few screws needed removing or when compressed air wasn't available. Figure 4-38 shows a typical hand-held impact tool.

Exercises (660):

1. What is the most important factor in determining whether or not an impact type of screw removal tool can be used?

2. What can result from using impact type of screw removal tools in areas not suited for their use?

3. Why isn't maximum striking force required to effectively loosen screws?

4. Why shouldn't a screw be completely removed using an impact type of screw removal tool?

5. What safety precautions should you take when using impact type of screw-removal tools?

661. Specify various procedures for using a screw punch or fastener removal tool to remove corroded or overtorqued screws.

There are two other methods that can be used to remove a corroded or overtorqued screw before it becomes necessary to use drilling removal procedures. These methods are the fastener removal tool method and the screw punch method.

Fastener Removal Tool Method. Figure 4-39 shows a typical fastener removal tool. It is primarily designed to use on flat surfaces. On surfaces having any degree of contour, the needed "in-line" alignment requirement will be hard to obtain. The tool is used in the following manner:

a. The foot of the tool is positioned under the head of an adjacent fastener location. This adjacent fastener must be within the range of the travel distance of the sliding driver adapter holder. This adjacent fastener is then tightened, holding the foot in place.

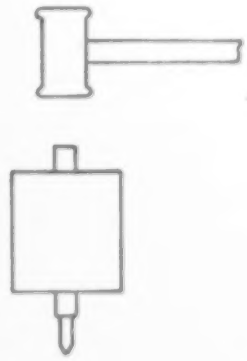
b. The sliding driver adapter holder is then adjusted on the handle until the holder is directly over and in line with the screw to be removed.

c. The driver bit is then inserted into the screw's recess, and end-load pressure is applied by pressing downwards on the handle *not* the "T-handle."

d. While maintaining the end-load pressure, the removal torque is then applied by rotating the "T-handle." Once the screw is broken loose, release the end-load pressure to keep from damaging the threads of the parent receptacle (nut plate). If more than one screw is being removed, repeat the steps over again.

Hammer/Punch Method. This method involves using either a center punch or a screw punch to hammer on the outer edge of the screwhead, as shown in figure 4-40, to rotate it. However, the point of the center punch does more gouging than rotating; therefore, a screw punch should be used. A machinist should be able to fabricate a screw punch for you. The only drawback from either of the two methods is that the screw head or recess is damaged and the fastener must be replaced. So these methods should be used as a last resort before drilling is required.

When using the screw punch, hold the tool at about a



CAUTION

Hold impact driver firmly in place in recess when striking with hammer to avoid "jump-out" and resultant skin damage.

Figure 4-38. Manual impact driver.

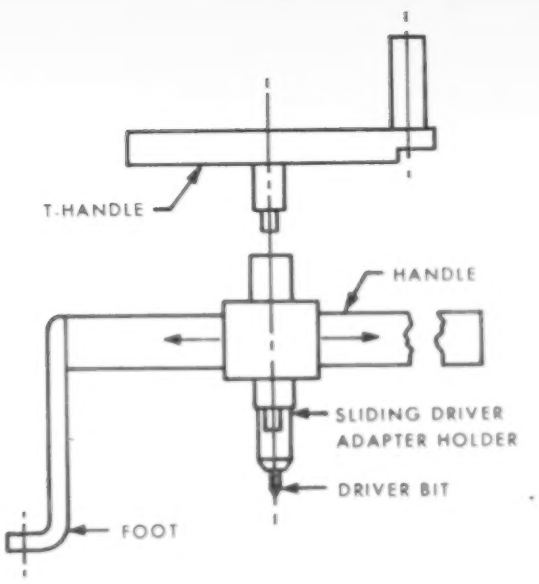


Figure 4-39. Fastener removal tool.

10° to 15° angle to the axis of the screw with the bottom edge of the tool near the outer edge of the screw and preferably in line with one of the screw recess extensions. By striking the tool a couple of times in this position, the tool will be securely seated in the screwhead. Then the tool can be angled back about 30° to 45° to the axis of the screw. A series of light taps with the hammer usually does more to rotate the screw than heavy blows. With heavy blows, you run the risk of driving the tool off the screwhead and causing it to scratch or gouge the surrounding surface.

As with the pneumatic hammer method, this removal method should be used only where there is sufficient support behind the surface containing the screws. Also, the screw should be merely broken loose or turned about one-fourth of a turn with the tool in order to prevent damage to the parent thread. After it has been loosened, you can easily remove the screw with a screwdriver or speed handle.

Exercises (661):

1. What is the purpose of holding the screw punch nearly in line with the screw's axis during the first couple of hammer blows?

2. Why should you not use heavy hammer blows on a screw punch?

3. Why is a screw punch preferred over a center punch?

4. What factor must be taken into consideration before using a screw punch?

5. How is it possible to apply the needed end-load pressure when using a fastener removal tool?

6. What factor determines whether or not you can use a fastener removal tool in a certain area of the aircraft?

662. Point out various aspects of the removal methods used to remove screws that involve drilling.

There will be many instances when you must resort to drilling to remove damaged or corroded screws. For instance, on surfaces that are weakly supported, the penumatic hammer, the screw punch, or even heavy pressure on a speed handle could cause damage to the surrounding skin area. There are several ways in which drilling can be used to aid in removing screws, but it will be up to you to decide which method to use in any given situation. Even though a method might work well in one instance, it might be the worst choice in another similar instance.

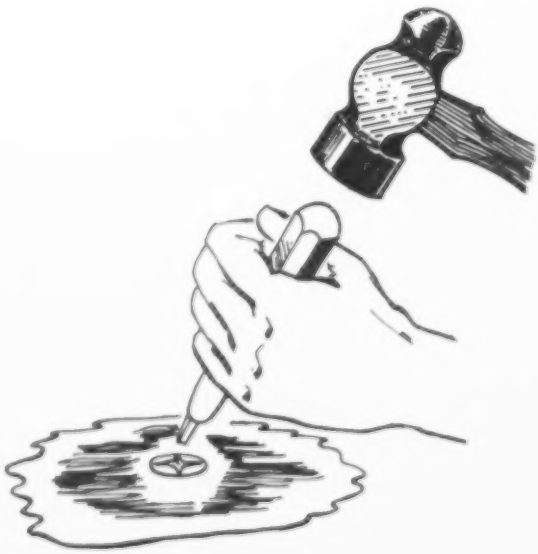


Figure 4-40. Punch/screw punch removal procedure.

Drilling Off the Screwhead. This method involves using a twist drill to drill through the screwhead and thus separating it from the shank of the screw. This method is most useful when an entire surface panel is being removed and several screws are badly damaged. By drilling the heads off, the panel can be removed, leaving the shanks of the screws extending slightly above the substructure. Normally, you can easily remove the shank of the screw with a pair of self-locking pliers. To reduce the possibility of breaking or chipping the twist drill during the initial drilling stage, it is recommended that you rotary file the screw recess area to remove any sharp edges. A small ball-type rotary file should be used so as not to damage the surrounding skin area.

Drilling for Stud/Screw Extractors. In situations where just drilling off the screwhead isn't practical, or the screwhead is off and you need to remove the shank portion of the screw, you must drill the screw so that an extractor, better known as an *ezy-out*, can be used. Two types of ezy-outs are available—the commercial type shown in figure 4-41, and the ground tool type shown in figure 4-42. The commercial ezy-out has a square tapered body with a left-hand thread. When it is inserted into the drilled hole, it tends to screw in and lock in position. The ground tool type of ezy-out is made from a tool bit which tapers to a square point and has flat sides. When inserted into the drilled hole, the sharp edges of the side lock themselves into the walls of the screw. When making this type of ezy-out, be careful not to allow the tool bit to overheat during the grinding. If it becomes hot enough to darken the metal, the chances are increased that it will break during screw removal.

You can normally remove a screw with an ezy-out if you use the proper amount of pressure to turn it out and if you have drilled the hole in the screw as close to the center of the screw as possible. However, the ezy-out will not always remove the screw and it is easily broken by too much twist pressure. For ordinary conditions, the makers of ezy-outs recommend the drill sizes shown in figure 4-43. Unusual conditions may require the use of larger drill sizes, depending upon the length of the broken part or its depth in the substructural part. You should turn the ezy-out or the ground tool with even pressure. The best way of doing this is to use either a tap wrench or two wrenches placed opposite one another on the extractor shank, applying pressure equally to both wrenches. Equal pressure is especially important in the initial loosening of the screw. Usually, once a screw is loosened in this manner, it will screw out of the hole without further difficulty. But if the screw is badly corroded, the extractor will either slip out or break when you apply the twisting force. You should always use the largest screw extractor possible to prevent this from happening.

It is important when using either a commercial ezy-out or a ground tool that you drill the screw through its entire length. Then, if the ezy-out or ground tool should break off inside the screw while you are attempting to remove it, the broken off piece can be

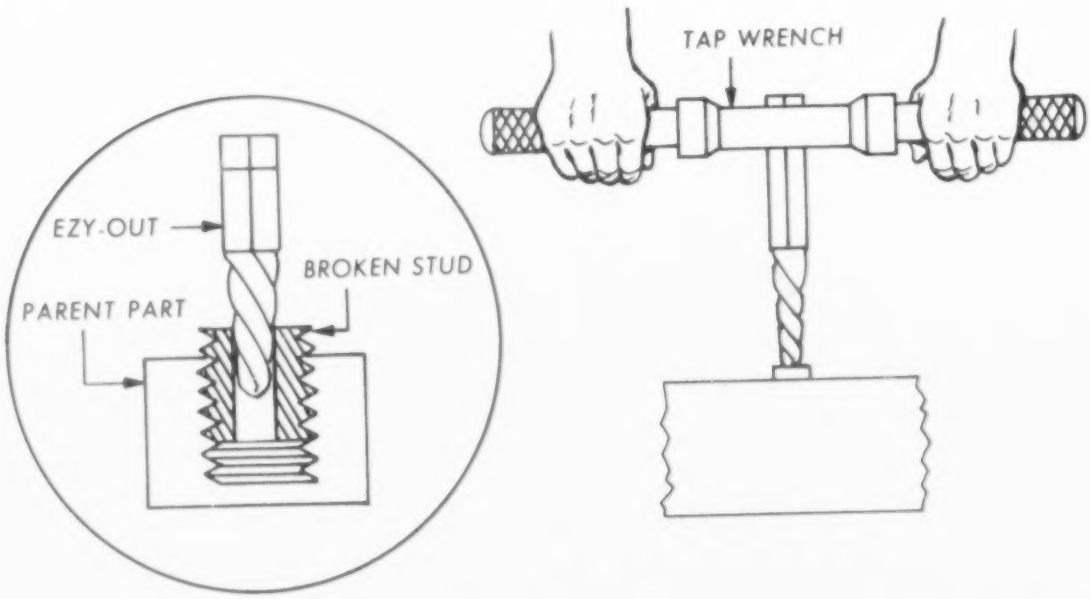


Figure 4-41. Commercial ezy-out.

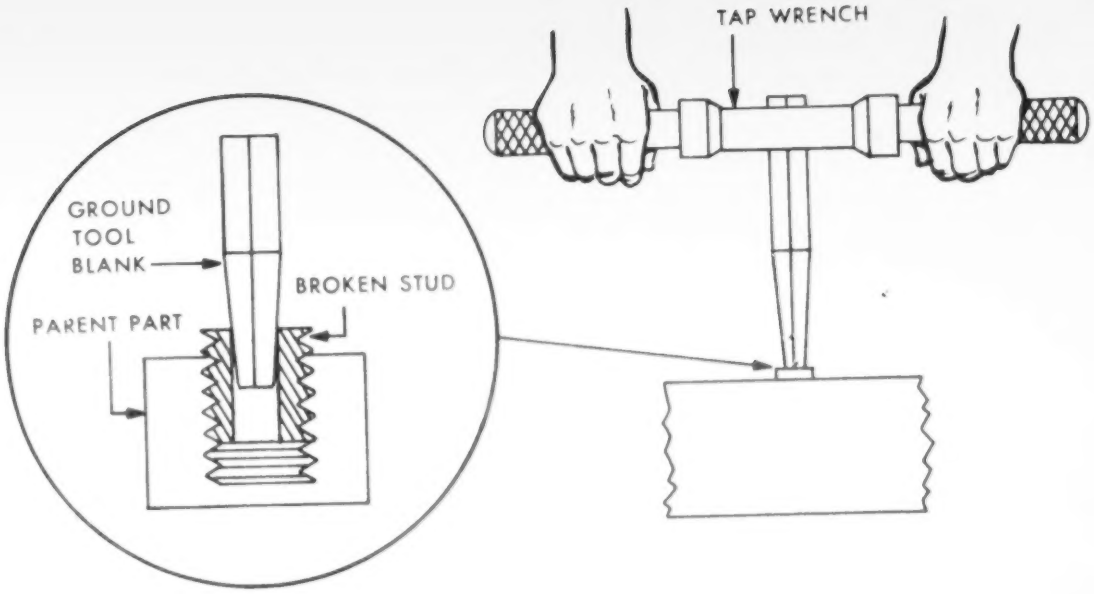


Figure 4-42. Ground tool bit extractors.

driven down and out the bottom end of the screw. The screw can then be drilled out without damaging the drill on the hardened piece of extractor.

A point to remember when inserting an extractor into a screw is to tap it in only sufficiently to seat it tightly. If you drive it in hard enough to break the wall of the screw, removal becomes much more difficult; also, the danger of damaging the threads in the locking device is greatly increased. In addition, it is usually best not to drill the head of the screw off before drilling for an extractor because the head will offer some support when you tap the extractor into the screw.

Tap Drilling. There are times when drilling the entire screw out is the only way of removing it. When this is the case, you must be very careful to protect the parent threads (usually a nut plate). The success of this operation depends to a great degree on how well centered your first or pilot hole is. With a nut plate you have an added problem in that some nut plates "float" in their sockets, making it difficult to keep the drilled hole straight with the axis of the screw. It is usually best to choose a final drill that is one size under the top drill size. This smaller size will help prevent thread damage in case your pilot hole was slightly off center.

Sometimes you will be lucky and the final drill bit size drilling will loosen the screw sufficiently so that the

Extractor Number	For Fastener Sizes (Inches)	Size Drill to Use
1	3/16 to 1/4	5/64
2	1/4 to 5/16	7/64
3	5/16 to 7/16	5/32
4	7/16 to 9/16	1/4
5	9/16 to 3/4	17/64
6	3/4 to 1	13/32
7	1 to 1 3/8	17/32
8	1 3/8 to 1 3/4	13/16
9	1 3/4 to 2 1/8	1 1/16
10	2 1/8 to 2 1/2	1 5/16
11	2 1/2 to 3	1 9/16
12	3 to 3 1/2	1 15/16

Figure 4-43. Recommended drill and extractor sizes.

remaining threads will catch on the drill, before it goes completely through and will spin through the nut plate and drop off. If the screw does not spin out of the nut plate, then you will have to pick the remaining threads out with a scribe.

Exercises (662):

1. Under what circumstances would drilling off the head of a screw be most practical?

2. Normally, should the head of a screw be drilled off prior to using an extractor?

3. What special problem do you encounter when you must drill a screw out of a nut plate?

4. Why shouldn't an extractor made from a tool bit be allowed to overheat during grinding?

5. What can result from driving an extractor too deep into a screw?

6. What is an important rule concerning the location of an extractor hole in a screw?

7. If a tap wrench is not available, how should an extractor be turned initially?

657 - 1. a. Frearson (Reed & Prince).
b. Torq-set.
c. Hi-torque.
d. Slotted.
e. Torx.
f. Tri-wing.
g. Torq-set.
h. Phillips.
i. Socket.
j. Hi-torque.

657 - 2. The standard head is larger in diameter and is used where tensile stress is of prime concern. The reduced head is smaller and used where side motion or stresses are the primary concern.

657 - 3. Either by the NAS codings on the head of the fastener or by the panel fastener decal, if the panel has one.

657 - 4. Reduced head styles call for smaller removal tools.

657 - 5. So that you can select the proper size removal tool.

658 - 1. The factors that influence your driver bit tool selection are: how many fasteners are being removed, the shank diameter of the fasteners, the amount of installation or removal torque, and work clearance.

658 - 2. The Phillips has a blunt point, whereas the Frearson has a sharp point.

658 - 3. By looking directly down at the driving wings, you can easily see the torq-set "off-centered" arrangement of its driving wings.

658 - 4. So that the driver tool will lock properly within the recess.

658 - 5. Because of the curved bottom of the hi-torque recess.

658 - 6. The circular blade can be rotated when one portion becomes worn or chipped, whereas the solid blade driver must be replaced.

659 - 1. So as not to be the cause of additional damage or be "an accident looking for a place to happen."

659 - 2. To insure that the driver bit is fully inserted into the recess, thereby reducing the possibility of "early" slippage.

659 - 3. To insure that the correct length fastener is reinstalled in its original location.

659 - 4. To reduce the possibility of driver bit slippage.

659 - 5. To keep from damaging the internal locking devices.

659 - 6. To prevent "snap loading" the driving wings of the recesses which usually results in damage to the recess.

659 - 7. To check and insure the proper mating of threads between the fastener and the locking device before torque is applied.

659 - 8. Because any additional clockwise torque will greatly increase the require removal torque which may be beyond the material capability of the fastener's recess, resulting in cam-out.

659 - 9. This is the necessary tool alignment term indicating that the driver tool must be held 90° from the head of the fastener.

659 - 10. To reduce the chances of misplacing the removed fasteners by insuring those already loose are not placed on the ground or aircraft where they can be stepped on.

660 - 1. The internal support of the area around the screws.

660 - 2. The surrounding area can be dented or the screw can be forced through it.

660 - 3. Because it's the vibration rather than the heavy blow that breaks the screw loose.

660 - 4. After about one-fourth turn, the blows from the impact tools will begin to damage the parent threads or nut plate.

660 - 5. Wear safety glasses and make sure that the tool is in contact with the screw head before starting any hammering action.

661 - 1. To seat the bit securely in the head of the screw.

661 - 2. Heavy blows can cause the punch to slip off the screw head and damage the surface around it.

661 - 3. Because the center punch does more gouging than rotating.

661 - 4. The amount of internal support under the area containing the screws.

661 - 5. By inserting the foot under an adjacent fastener and aligning the sliding driver adapter holder in line with the screw to be removed and applying downward pressure on the handle.

661 - 6. The contour of the area where the screws needing removal are contained.

662 - 1. When an entire panel that contains several damaged screws is be removed.

662 - 2. No, the head will offer added support when the extractor is being seated in the screw.

662 - 3. Some nut plates are the floating type, making alignment impossible.

662 - 4. Overheating can cause the tool bit to break during use.

662 - 5. It can cause the screw walls to break, making screw removal more difficult, and it may damage the parent threads.

662 - 6. It should be centered in the screw.

662 - 7. With two wrenches placed opposite each other on the extractor shank so that the pressure applied will be even.

STOP-

1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.

2. USE NUMBER 2 PENCIL ONLY.

53153 04 21

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

FASTENING METHODS

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if a all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DON'TS:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed*. Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

Multiple Choice

1. (600) What is the maximum length of the (friction lock) rivet used for material having a thickness of 3/16 of an inch?

   a. 3/16".
   b. 4/16".
   c. 15/64".
   d. 20/64".

2. (600) Self-plugging (friction lock) blind rivets are used to replace solid shank rivets

   a. whenever possible.
   b. in heavily stressed areas of an aircraft.
   c. only when absolutely necessary and allowed by technical order specifications.
   d. only when the next larger size (friction lock) blind rivet is used in place of the original diameter.

3. (601) The proper size twist drill needed to drill holes for installing RV200-5-2 self-plugging (friction lock) blind rivets is

   a. #30.
   b. #20.
   c. #10.
   d. #F.

4. (601) To insure that self-plugging (friction lock) blind rivets are properly installed, the hole clearance should be no less than

   a. 0.002 of an inch.
   b. 0.003 of an inch.
   c. 0.004 of an inch.
   d. 0.006 of an inch.

5. (602) A gap between the head of a countersunk (friction lock) blind rivet and the surface is permitted provided that

   a. the locking collar is locked in place.
   b. the gap does not exceed 0.004 of an inch.
   c. the gap can be filled with aerodynamic sealer.
   d. 60 percent of the rivet head is bearing against the surface of the hole.

6. (602) Which one of the following directly influences the need for a stem retention test of an installed self-plugging (friction lock) blind rivet?

   a. Grip length and hole diameter used.
   b. Head style of the rivet and installation tool used.
   c. Material composition of the sleeve and the material in which the rivet was installed.
   d. Material composition and thickness of the material in which the rivet was installed.

7. (603) Whether an installed blind rivet is a friction lock or mechanical lock type can be easily identified by the

   a. absence of the stem.
   b. diameter of the rivet.
   c. presence of a locking collar.
   d. stem being flush with the manufactured head.

8. (603) A work situation involving thick material and countersunk rivet holes requires the use of what type of (mechanical lock) blind rivet?

   a. Bulbed.
   b. Standard.
   c. Oversized.
   d. Pull-thru.

9. (604) The type of installation tools used to install (mechanical lock) blind rivets is directly influenced by all of the following except the

a. availability of an air supply.
b. location of existing fasteners.
c. accessability of the work area.
d. quantity of rivets to be installed.

10. (604) Of the following drills, which one should be used during the installation and removal of a bulbed-type self-plugging (mechanical lock) blind rivet having a rivet diameter of -4?

a. F.
b. #5.
c. #16.
d. #27.

11. (605) Gaps between faying surfaces of riveted members must not exceed what percent of the thickness of the thinnest member when measured at the shank of the fastener during inspection of a self-plugging mechanical lock blind rivets?

a. 30.
b. 25.
c. 10.
d. 5.

12. (606) The use of pull-thru blind rivets to install structural hardware, such as nut plates, eliminates all of the following except

a. deformed nut plates caused by a misplaced bucking bar.
b. damage to the skin surface caused by excessive riveting pressure.
c. the use of irregular shaped bucking bars.
d. the aerodynamic smoothness requirements of the manufactured head.

13. (606) Why is it necessary that a nut plate, being installed using pull-thru blind rivets, be tightly clamped against the surface?

a. A shorter grip length can be used.
b. To reduce the number of strokes required to install the rivets.
c. To keep the rivet from swelling between the contacting surfaces.
d. A larger bucking bar can be used because of added back side clearance.

14. (606) When removing a pull-thru blind rivet, which of the following procedures is the best to follow?

a. Reduce the RPM of the drill to keep from work-hardening the rivet head.
b. Lightly center punch the head of the rivet to provide a starting point for the twist drill.
c. make sure not to damage the countersunk or dimpled area of the hole.
d. Split the head of the rivet with a chisel prior to drilling off the head.

15. (607) Hi-shear pin rivets are designed to be used

a. only in shear application.
b. where the grip length is less than the shank diameter.
c. in applications where they are approximately twice as strong as solid shank rivets.
d. in applications requiring about one-half as much time for installation as a bolt, nut, and washer combination.

16. (607) Locking collars used with Hi-shear rivets are fabricated from all of the following except

a. monel steel.
b. aluminum alloy.
c. titanium alloy.
d. stainless steel.

17. (607) Regardless of the method used to determine the correct grip length of a Hi-shear rivet, the straight portion of the shank should

a. be flush with the top of the locking collar.
b. extend no more than 1/16 of an inch through the material.
c. be flush with the back edge of the material thickness.
d. extend at least 1/16 of an inch beyond the top edge of the locking collar.

18. (608) To install Hi-shear rivets, you will need a pneumatic riveting hammer and a

a. tapered drill.
b. standard bucking bar.
c. hollow drift punch.
d. special pneumatic pull gun.

19. (608) Proper "sealant squeeze out" from faying surfaces during installation of Hi-shear rivets is accomplished by

a. swaging the collar with an undersized swaging set.
b. increasing the hammering force needed to swage the collar.
c. installing temporary fasteners in every other hole prior to installation.
d. lightly tapping the Hi-shear rivet pin into the hole before swaging the collar.

20. (609) Locking collars fabricated from 6061-T6 used with standard aluminum stump-type lockbolts are color coded

a. red.
b. gray.
c. black.
d. silver.

21. (609) Which of the following lockbolts is available in the oversize diameter of 1/4 and 5/16 of an inch?

a. Pull.
b. Swage.
c. Blind.
d. Stump.

22. (610) The swage set used to install lockbolt fasteners can be distinguished from the rivet set used to install Hi-shear rivets by the

a. different color codes.
b. absence of an ejection port.
c. presence of a recessed area at the tip.
d. difference in weight and surface finish.

23. (610) The CP352 pneumatic rivet pull gun is especially designed for use with

a. use with blind-type lockbolts.
b. the rapid easy driving of aluminum lockbolts.
c. driving steel pull-type lockbolts up to 1/4 of an inch in diameter.
d. pulling aluminum stump-type lockbolts up to 1/4 of an inch in diameter.

24. (611) Which of the following would make it necessary to spotface the area under the locking collar of stump and pull-type lockbolts?

a. Whenever the lockbolts are used in areas requiring high tensile strength.
b. When the lockbolts are installed in extruded structures.
c. When the surface exceeds 7° from a perpendicular with the axis of the hole.
d. When the lockbolts are used in shear applications requiring an interference fit.

25. (611) Blind-type lockbolts can be installed in all of the following areas except

a. oversized blind holes.
b. for replacing steel AN and MS bolts in shear applications.
c. where the back-side sheet is 0.020 of an inch or less in thickness.
d. where the combined sheet thicknesses equal the diameter of the lockbolts.

26. (612) Which of the following can be used on flush head aluminum lockbolts to meet aerodynamic smoothness requirements?

a. Shaving.
b. Spotfacing.
c. Sand blasting.
d. Sub-countersinking.

27. (612) What percentage of the fastener head of flush head lockbolts must be in contact with the surface before a gap is permitted by TO specifications?

a. 20.
b. 40.
c. 60.
d. 80.

28. (612) When using the conventional method of removing lockbolt fasteners, which of the following tools is required?

a. Chisel.
b. Pin puller.
c. Twist drill.
d. Radius cutter.

29. (613) A lightweight countersunk head style and a compact protruding head style Hi-Lok fastener are used in areas requiring high

a. shear strength.
b. compressive force.
c. tension resistance.
d. torsional resistance.

30. (613) Hi-Lok pins are available in all of the following material composition except

a. titanium alloys.
b. magnesium alloy.
c. aluminum alloy (7075-T6).
d. corrosion resistant steel.

31. (613) Which type of material composition Hi-Lok pin would you select for areas of the aircraft where the temperature is 900° F.?

a. Aluminum alloy.
b. Titanium alloy.
c. Corrosion resistant steel.
d. High temperature magnesium alloys.

32. (614) What is the limiting factor concerning the use of washers with Hi-Lok pins?

a. They are only used on tapered surfaces.
b. The maximum total washer thickness is 0.032 of an inch.
c. Only one washer is allowed and that is used only under the locking collar.
d. Washer thickness should be equal to one-half the diameter of the Hi-Lok pin.

33. (614) It is recommended that the maximum interference fit required for Hi-Lok fastener holes shall not exceed 0.002 of an inch

a. because any larger clearance requires an oversized diameter fastener.
b. in order to avoid building up excessive internal stresses in the work piece adjacent to the hole.
c. as this allows the Hi-Lok pin to be reused when carefully removed.
d. due to the fact that all Hi-Lok pins are fabricated 0.002 of an inch.

34. (614) Before torquing the locking collar onto a Hi-Lok pin,

a. the torque-ring must be separated from the locking collar.
b. make certain that the head of the pin is above the surface of the material.
c. a minimum of two threads (3/4 of a turn) must be engaged.
d. the Allen wrench is removed after the head of the pin is flush against the surface.

35. (615) Inspector of the locking collar of an installed Hi-Lok fastener involves visually checking the physical features of the locking collar and

a. pin protrusion.
b. fillet clearance.
c. counterbore limitations.
d. pin recess area alignment.

36. (615) Which of the following tools would be unnecessary when removing a Hi-Lok fastener installed into interference fit holes?

a. Punch.
b. Hammer.
c. Allen wrench.
d. Ratchet wrench.

37. (616) Fewer Taper-Lok fasteners are required when making a repair because they

a. are available in larger diameters.
b. are able to fasten thicker parts together.
c. have load distribution and high joint integrity.
d. have locking grooves built into the tapered portion of the shank.

38. (616) A 60° countersunk head Taper-Lok pin is used in areas where

a. shear strength is required.
b. tensile force must be reduced.
c. compressive resistance is not a factor.
d. clamping action result during swaging operations.

39. (616) Besides eliminating centering problems, what other problem is eliminated by having a stationary washer attached to the nut?

a. Washer fumbling.
b. Over-torquing of the nut.
c. Corrosion of the material surface.
d. Mis-match of pin and not material compositions.

40. (617) When is it necessary to replace a Taper-Lok fastener with a slightly oversized diameter Taper-Lok, you would select one from

a. the same group within the same series.
b. a different group within the same series.
c. a completely new series, starting at the lowest group.
d. the series containing the oversized grouping for all series Taper-Lok.

41. (617) What is added to the head marking symbols on the head of Taper-Lok pins to indicate that the pin is an injection type?

a. The letters I T
b. The letters ST are used after the last dash number.
c. The numbers representing the type sealant required.
d. A second dash number indicating the depth of the injection parts.

42. (618) To properly select the correct drill-reamer for use when installing Taper-Lok fasteners, you must

a. interpret the head markings on the pin.
b. figure the load distribution and joint strength requirements.
c. match the grip length of the pin to the front two cutting flutes.
d. measure the pin protrusion prior to torquing the washer-nut in place.

43. (618) Because the front two cutting flutes of a Taper-Lok drill-reamer do not cut when being withdrawn from a hole,

a. a true clearance fit is formed.
b. the drill-reamers stay sharper for a longer period of time.
c. the diameter of the hole is more accurate than could be obtained by straight drills.
d. the cutting tips may vary as much as 0.005 of an inch and still produce a precision hole.

44. (618) Prussion Blue Oil-Color is applied to the shank of Taper-Lok fasteners

a. for lubrication.
b. to prevent corrosion.
c. in order to distinguish between standard and injection-type Taper-Loks.
d. to check the amount of surface bearing against the fasteners.

45. (619) At what time during the drilling of Taper-Lok holes is it necessary to increase the drilling pressure?

a. While the countersunk area is being formed.
b. While the back flutes are forming the tapered hole.
c. Prior to cutting the countersunk portion of the hole.
d. At the very beginning of the drilling because of the difference in cutting tip angles.

46. (620) Distortion on the head of Taper-Lok fastener is evidenced by

a. a gap under the head.
b. cracks developing across the head.
c. a separation of the head from the shank.
d. the appearance of a distinct ring on the head of the fastener.

47. (620) The substitution of another type of hi-strength fastener as a replacement for a Taper-Lok fastener is

a. not authorized.
b. permitted only on a one-to-one ratio.
c. allowed as long as an increase in diameter is not required.
d. based on shear and tensile strength requirements in the joint.

48. (621) The individual parts that make-up a Jo-Bolt fastener consists of

a. an expander, a core bolt, and steel nut.
b. an expander, aluminum nut, and a corrosion resistant steel collar.
c. steel nut, a corrosion resistant steel sleeve, and aluminum locking collar.
d. an aluminum alloy or steel nut, a corrosion resistant steel sleeve, and a threaded alloy steel bolt (screw).

49. (621) If the part number given for Jo-Bolt fasteners on a repair illustration reads FF 164-8, what does the -8 indicate?

a. Diameter.
b. Head style.
c. Grip length.
d. Taper condition.

50. (622) The method you will use to measure the grip length of Jo-Bolts will depend on what physical feature of the Jo-Bolt?

a. Diameter.
b. Head style.
c. Material composition.
d. Thread size.

51. (622) For best results, holes for Jo-Bolts should be

a. drilled with a twist drill slightly undersized.
b. drilled oversized to permit proper sleeve formation.
c. reamed producing an interference fit in steel structures.
d. drilled under size and then brought up to final size by reaming.

52. (623) Which of the following existing conditions would require removal and replacement of installed Jo-Bolt fasteners?

a. Steel head Jo-Bolts shaved to meet the flush requirements.
b. The torque valve for 1/4 of diameter Jo-Bolts is 10 inch-pounds.
c. A flush head Jo-Bolt installed inside a wheel-well extends 0.005 above the surface.
d. The spacing between the flush head Jo-Bolts is equal to four times the diameter of the Jo-Bolts.

53. (624) When a Jo-Bolt fastener is loose and rotating in the hole, which of the following removal procedures is not required?

a. Pilot-drilling.
b. Severing the bolt head.
c. Using a drill-bushing fixture.
d. Removing the nut from the hole with a punch.

54. (624) When a Jo-Bolt fastener is tight and needs to be removed, which of the following removal tools is unnecessary?

a. Hammer.
b. Punch.
c. Pilot drill.
d. Drill-bushing fixture.

55. (625) Hi-Shear threaded blind bolts

a. consist of a four-piece fastener.
b. of a large diameter have Phillips recess heads.
c. are designed only for areas having temperatures up to 100° F.
d. of the sealing type are made in the countersunk head style only.

56. (626) To insure that the maximum strength for Hi-Shear threaded blind bolts is obtained, the

a. sleeve should be coated with a anti-rotation sealer.
b. holes should be pilot-drilled and then reamed to final hole size.
c. holes should be counterbored to one-half the thickness of the head.
d. sleeve should be drawn into the hole by the rotation of the expander.

57. (625) The Hi-Shear threaded blind bolt with a part number BB351-8-12, would be a

a. countersunk blind bolt, that is 1/4 of an inch in diameter with a grip range of 3/4 of an inch.
b. flush millable head blind bolt that is 1/2 of an inch in diameter with a grip range of 7/8 of an inch.
c. protruding head blind bolt that is 1/4 of an inch in diameter with a grip range of 3/4 of an inch.
d. hex head blind bolt that is 5/16 of an inch in diameter with a grip range of 9/16 of an inch.

58. (626) When is the crow foot wrench used during the installation of Hi-Shear threaded bolts turned in a counterclockwise direction?

a. After the core bolt is installed.
b. During the sleeve insertion into the hole.
c. When setting the expander into the sleeve.
d. To release the tool body from the expander's threads.

59. (627) If a protruding head-type Hi-Shear threaded blind bolt has a gap of 0.005 of an inch at the nearest point between the head and the work surface,

a. replace it.
b. do nothing to it.
c. apply additional torque to remove the gap.
d. lightly hammer the head until the gap is removed.

60. (628) A mechanical-lock blind bolt consists of a

a. shank and pulling pin.
b. separate locking device and pulling pin.
c. long cylindrical sleeve, a self-locking nut and self-aligning washer-nut.
d. tapered sleeve, an internally threaded shank and separate insertion bolt.

61. (629) When replacing existing mechanical-lock blind bolts, the first step after removal is to

a. measure the diameter of the existing hole.
b. measure the thickness of material being fastened.
c. drill the existing hole for an oversized replacement blind bolt.
d. apply a coating of zinc chromate primer to the walls of the existing hole.

62. (629) If you were assigned the job of installing 1/4 to 1/2 of an inch diameter blind bolts, it would be necessary to select a

a. double action installation gun with an attached protruding head adapter.
b. drill motor capable of turning at 1000 RPM for use with a 3/16 of an inch diameter drill-reamer.
c. drill motor capable of turning at a controlled speed of 500 RPM for use with a 1/4 of an inch counterbore.
d. single action pulling gun with an attached flush head nose adapter that matches the head style and diameter of the blind bolt.

63. (629) At what point during the installation of a mechanical-lock blind bolt is the locking collar automatically forced into the conical space between the recess in the head and the locking groove in the pin?

a. After the pin breaks off.
b. Once the blind head has been formed.
c. Prior to the shop head formation.
d. At the same time the pin breaks off.

64. (630) Inspection of installed mechanical-lock blind bolts is limited to three specific areas of the manufactured head. This includes the fit of the manufactured head against the work surface, the

a. thread protrusion, and the core bolt flushness.
b. position of alignment slots, and the locking collar position.
c. pin break off position, and the tightness of the core bolt.
d. position of the pin, and the position of the locking collar.

65. (630) At what point during the removal of mechanical-lock blind rivets is it necessary to use an adjustable micro-limit cutting tool?

a. After the sleeve has been removed.
b. When the locking collar has been removed.
c. At the very beginning, to remove the top portion of the pin.
d. After the lower portion of the pin is punched out of the sleeve.

66. (631) The heavy-duty type of Dzus turnlock fastener, usually found on the exterior of the aircraft for security the engine cowling, consists of a stud,

a. a spring, cup and receptacle assembly.
b. a grommet, and either a spring or receptacle.
c. cross-pin, spring cup, and extruded receptacle.
d. locking spring, stud cup, and floating receptacle.

67. (631) If a turnlock receptacle has a heat-treated steel base and cadmium plated music wire springs, what type of Dzus fastener is it?

a. Light-duty.
b. Heavy-duty.
c. Anti-corrosion.
d. High-temperature.

68. (632) It is necessary to make the hole in the substructure for flush-type Dzus turnlock fasteners 3/16 of an inch larger than the hole drilled in the panel for the stud in order to

a. insure stud and locking spring alignment.
b. provide clearance for the grommet after dimpling.
c. provide a recess for the retaining ring around the stud.
d. prevent the locking spring from interfering with the rotation of the stud.

69. (633) The forming block used during the swaging of the cup of a light-duty type Dzus turnlock to a panel has a

a. countersunk recess at the center.
b. counterbed hole equal to the diameter of the stud.
c. circular protrusion equal to the diameter of the panel hole.
d. circular protrusion equal to the inside diameter of the stud.

70. (634) When describing a 4002 series Camloc turnlock fastener, all of the following terms are used except

a. stud retaining ring.
b. grommet retaining ring.
c. music wire locking spring.
d. preassembled stud assembly.

71. (635) Selecting the correct male and female dimple dies is associated with installing what part of the 4002 series Camloc turnlock fastener?

a. The stud retaining grommet.
b. The floating-type receptacle.
c. The preassembled stud assembly.
d. The 1100 aluminum alloy grommet.

72. (636) What classification is used to identify the size of an Airloc turnlock fastener receptacle which has a riveting spacing of 0.775 (3/4) of an inch?

a. #1.
b. #2.
c. #5.
d. #7.

73. (637) To install a new flush-type Airloc turnlock fastener, the size of the punched hole in the access panel should be

a. 1/32 of an inch larger than the stud.
b. equal to the diameter of the stud.
c. 1/16 of an inch smaller than the stud.
d. approximately the same size as the diameter of the stud shank.

74. (637) How would you determine the grip length of an Airloc stud required when using a nonfloating receptacle?

a. Add the material thicknesses together then add 0.010 of an inch.
b. Add the material thicknesses together then add 0.030 of an inch.
c. Measure the distance from the top of the access panel to the backside of the substructure.
d. Measure the distance from the bottom of the juncture of head and shank of the stud to the hole for the cross-pin.

75. (638) All of the following apply to the structural Camloc turnlock fastener except

a. the number stamped on the head of the stud indicates the minimum and maximum grip thicknesses.
b. retaining rings are available in both flat and cone shaped designs for thin and thick dimpled materials.
c. the receptacle assembly consists of an adjustable threaded insert, a rivet attachment assembly, and an outer cover.
d. when the total thickness of the material being fastened is more than 0.158 of an inch, a shim is not required under the receptacle.

76. (639) Internal threads built into the shank portion of the sleeve bolt of a Milson fastener permit the

a. insertion of a Hi-Shear set screw.
b. mounting of a retaining plate on the substructure.
c. retention of a sleeve bolt in the access panel.
d. sleeve bolt to be screwed into the receptacle.

77. (639) Which of the following identifies the correct retaining ring and colored installation tool to use with -4 diameter Milson sleeve bolts?

a. A blue colored installation tool containing retaining rings with 8 notches.
b. A yellow colored installation tool containing retaining rings with 7 notches.
c. A red colored installation tool containing retaining rings with 4 notches.
d. A green colored installation tool containing retaining rings with 2 notches.

78. (640) Just by looking at the heads of structural turnlock studs, how is it possible to distinguish the Deutsch Zip-Lok from the Milson stud?

a. Torque-set screwdriver slots are prominent.
b. The sealant alignment groves are set within the recess.
c. A hex-shaped recess is provided for an Allen wrench.
d. The grip length number is stamped at the bottom of the hex-shaped recess on the head of Deutsch Zip-Loc fasteners.

79. (640) What physical feature of the Deutsch Zip-Loc stud would easily identify the Deutsch Zip-Loc stud from the Milson stud when only the bottom side of the studs are shown?

a. Internal shank threads.
b. Retaining ring tip lip.
c. Retaining ring alignment grooves.
d. Serrations on the bottom of the Deutsch Zip-Loc stud.

80. (641) What action would require use of a loading rod during the installation of the retaining plate for a Deutsch Zip-Loc fastener?

a. Countersinking the retainer plate attachment rivet holes.
b. Removing the receptacle after drilling the retainer plate rivet holes.
c. Counterboring the substructure for the dimple recess in the retainer plate.
d. Removing the stud after drilling and countersinking the retainer plate rivet holes.

81. (642) Calfax fasteners installed in countersunk holes, require that the substructure be counterbored and that you

a. use a flat retaining ring.
b. use a dimpled retaining ring.
c. place a shim under the receptacle.
d. double-flush the receptacle rivets.

82. (642) When installing Calfax fasteners in magnesium structures, use

a. a cadmium plate retainer plate.
b. 1100 aluminum alloy grommet inserts.
c. a tin plated stud assembly and retaining ring.
d. epoxy primer on the threads of the receptacle.

83. (643) Which of the following conditions would justify the statement, "If plate nuts are used with bolt installation, shims are added under the plate"?

a. The grip length of the bolt is excessive.
b. Floating types of plate nuts are used only in blind areas.
c. Where the material thicknesses being bolted together is less than the diameter of the bolt.
d. If the thread protrusion through the plate nut is more than the required two threads.

84. (644) An aircraft bolt designed for use where the bolted joint is subject to sever load reversals and vibration is

a. a hi-torque bolt.
b. a self-locking bolt.
c. a close tolerance bolt.
d. an internal wrench bolt.

85. (644) Which of the following bolts are fabricated from high-strength steel and are used where severe tension occurs?

a. Hi-torque bolts.
b. Self-locking bolts.
c. Close tolerance bolts.
d. Internal wrenching bolts.

86. (645) To produce a light drive fit when installing 3/8 inch diameter bolts, you would drill an initial hole approximately

a. 1/64 of an inch undersize.
b. 1/32 of an inch undersize.
c. 1/32 of an inch undersize, then redrill to 1/64 of an inch undersize.
d. 1/8 of an inch undersize, then redrill to 1/64 of an inch undersize.

87. (645) What condition would allow you to install steel washers when bolting aluminum structure together?

a. When zinc-chromate primer is applied first.
b. When high torque requirements are necessary.
c. If the aluminum structure is over a 1/2 inch thick.
d. If the temperature where the bolts are installed exceed 250° F.

88. (646) Aircraft screws which have a definite grip and tolerance similar to AN hex head bolts are classified as

a. machine screws.
b. structural screws.
c. fine-threaded screws.
d. coarse-threaded screws.

89. (646) In order for a screw to be classified as a machine screw, it should

a. be installed in undersize hole.
b. not be used to replace structural screws.
c. have the same shear strength as a bolt of equal size.
d. be used as a replacement for a structural screw.

90. (647) What is the result when bolts are tightened beyond their working loads?

a. Cross-threading of the nut.
b. Premature failure of the bolt.
c. There can be no fatigue failure.
d. A loss of torsional and tensional strength.

91. (648) When a bolted joint is subjected to both high heat and heavy pressures, which of the following plated finishes should be selected?

a. Silver.
b. Cadmium.
c. Titanium.
d. Aluminum.

92. (649) A dash number 3 following the material code letter in a nut part number would indicate that the nut is used with a

a. 300° F. bolt.
b. #3 class fit bolt.
c. 3/8 diameter bolt.
d. 10-32 threaded bolt.

93. (650) If you were installing drilled clevis bolts and threaded taper pins, the style of nut required would be

a. barrel.
b. shear.
c. point wrenching.
d. internal wrenching.

94. (651) When an assembly is frequently removed, you would normally install which one of the following non-self-locking nuts?

a. Light hexnuts.
b. Wing nuts.
c. Plain hexnut.
d. Castle nut.

95. (652) Which one of the following is used to differentiate between the two major types of self-locking nuts?

a. Diameters.
b. Installation tools.
c. Type of bolts used.
d. Point of torque application.

96. (653) All of the following statements related to the installation of aircraft nuts are correct except

a. any free-spinning type nut that requires less than 10 inch-pounds torque to remove, should be replaced.
b. stainless steel nuts can be used in areas where the temperature is limited to 800° F.
c. elastic stop nuts, after being tapped, are required to be heated to 250° F. to restore the locking element.
d. New self-locking nuts shall be used in any application of the aerospace vehicle where vibration could cause loosened nuts to be ingested by the engine.

97. (654) Where perfect alignment between the head of the bolt and the surface is required, it is necessary to use what type of washer?

a. Ball seat.
b. Plain lock.
c. Countersunk.
d. Tapered coned.

98. (655) If the locking arm of a quick-release type latch fails to operate after installation, your first action would be to check the

a. nylon insert alignment key.
b. access panel cutout clearance.
c. cross-pin protrusion allowances.
d. shop heads of the attachment rivets.

99. (656) What type of hinge assembly has rolled lobes (tangs) for hinge pin housings?

a. Formed.
b. Extruded.
c. Structural.
d. 360° rotation.

100. (656) A hinge assembly that is a stress carrying member of the structure to which it is attached is called

a. a formed hinge.
b. a primary hinge.
c. an extruded hinge.
d. an insertion hinge.

STUDENT REQUEST FOR ASSISTANCE

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AUTHORITY: 44 USC 3101. PRINCIPAL PURPOSE(S): To provide student assistance as requested by individual students. ROUTINE USES: This form is shipped with every ECI course package. It is utilized by the student, as needed, to place an inquiry with ECI. DISCLOSURE: Voluntary. The information requested on this form is needed for expeditious handling of the student's need. Failure to provide all information would result in slower action or inability to provide assistance.

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AIRFRAME REPAIR SPECIALIST

(AFSC 53153)

Volume 5

Specialized Repairs

Extension Course Institute

Air University

771

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THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

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Preface

THIS IS THE FIFTH and final volume of the *Airframe Repair Specialist* course. In previous volumes, your study of airframe repairs has been limited primarily to repairs involving the cutting and forming of sheet and extruded metal stock and fastening of repair parts with rivets, lock bolts, and other hardware. However, many of the parts used on today's modern aircraft are made of plastic, various types of fiberglass, and metal bonded components. Added to these are the aircraft systems involving the use of cable and tubing assemblies. Also the requirements for balanced control surfaces and optical alignment checks are included in the scope of what is required of an Airframe Repair Specialist.

You will find that this volume contains instruction in the inspection and replacement of transparent section in enclosures; inspection, repair, and replacement of mat molded, laminated, and various sandwich type fiberglass structures; and inspection and repair of metal bonded honeycomb panels. Instruction includes removal or damaged materials, mixing of adhesives and potting compounds, installation of glass cloth laminate and core materials, heat-curing processes, and finishing of repair surfaces. You will also find information to repair aircraft cables and tubing including inspection, use, and care of production tube benders and flaring machines. The last chapter is devoted to the principles and procedures associated with balancing and alignment of aircraft components.

Remember that specific procedures for accomplishing aircraft structural repairs and the maintaining tools and equipment must be in accordance with applicable maintenance manuals.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendation for its improvement, send them Tech Tng Cen (TTOXC), Chanute AFB IL 61868. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercises, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your question, send it to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 42 hours (14 points).

Material in this volume is technically accurate, adequate, and current as of August 1976.

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NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Plastic Structures

HAVE YOU EVER THROWN your plastic goggles in your toolbox? Have you placed tools on them? Did they become so scratched as to impair vision? If so, you now know that transparent plastics do not possess the surface hardness of glass. Since scratches impair vision, you must carefully handle transparent plastics to avoid damaging the surface. You will be working with plastics used for domes, gun turrets, bubbles, windows, radomes, and other enclosures of military aircraft. The optical qualities of transparent material used in such aircraft enclosures must be as good as those of the best quality plate glass. The quality must be such that personnel can locate and identify other aircraft in flight, maintain position in formation flying, sight guns accurately, and assure positive depth perception necessary to land aircraft safely at high speeds. In addition to visibility, you are concerned with strength, contour, and proper function of repaired units.

In this chapter you will study the properties and characteristics of transparent plastics and the various techniques, tools, and equipment used to inspect, repair, and install transparent section. The maintenance and repair of aircraft plastics can be greatly simplified if you have a thorough understanding of the properties involved.

1-1. Transparent Plastics

800. Given statements that characterize certain types and classes of transparent plastics, specify the type or class.

Classes. There are a number of different classes of transparent plastics in use today. Of the various classes, the two that you will be working with are the cellulose plastics and synthetic resin plastics.

Cellulose plastics. Cellulose plastics are the oldest group, and include celluloid. Other plastics that fall into this class are acetate, nitrate, ethyl cellulose, and butyrate. Cellulose is made of wood pulp and cotton linters mixed with various acids, such as nitric and acetic acids. The plastic made of the acetic acids, and known as a transparent cellulose acetate, is used for some aircraft enclosures. This type is used mostly for the smaller liaison planes and older aircraft. The disadvantages for its use on aircraft concern its poor weather resistance and its sensitivity to change of humidity. Cellulose nitrate, which is one of the toughest of all thermo-plastics, cannot be molded. Instead, it must be fabricated from preformed sheet, rod, or tube material.

Synthetic resin plastics. Synthetic resin plastics are the largest and most important group. Synthetic materials are derived from coal, air, water, urea, petroleum, ethylene, phenol, formaldehyde, etc. Products made from synthetic resins include acrylic plastic, nylon, vinyl, styrene, polyethylene, urea-formaldehyde, and others. Synthetic plastics are both of thermo-plastic and thermosetting type; they can be molded by the various molding processes using heat and pressure or laminated under high and low pressure, and are produced in flat sheets, rods, tubes, and many other shapes in the extruded form. These synthetic plastics may be opaque, transparent, or translucent. Transparent plastic transmits both light and sight or image, while translucent transmits light only and no image. The opaque plastics transmit no light or image.

Types. Transparent plastics are grouped into two types—thermosetting and thermoplastic.

Thermosetting plastic. Thermosetting plastics cannot be reheated and reformed. In the manufacture of thermosetting plastics, fillers, and fibers are added that result in a chemical change. And once the plastic sets, no reforming can be done. Once formed, thermosetting plastic products are not soluble or subject to attack by chemicals.

Thermoplastics. Thermoplastics may be reheated and reformed. In the manufacturing, no chemical change takes place. Thermoplastic materials have characteristics similar to those of sulphur and sealing wax. Sulphur is a hard, brittle material until it is exposed to heat. It then becomes soft and pliable; it has the consistency of a liquid if enough heat is applied.

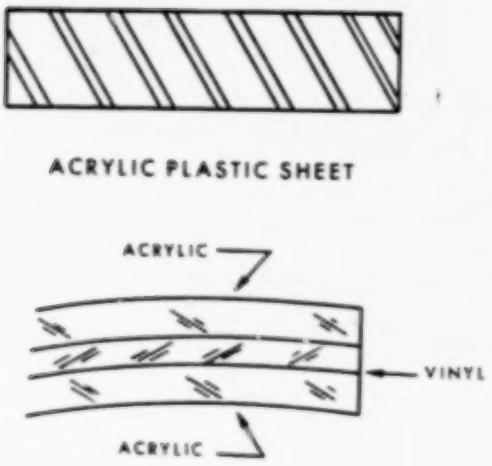

Figure 1-1. Types of transparent acrylic plastic enclosure.

After cooling, sulphur again becomes hard and brittle. However, any time it is reheated, it can be cast or molded into any desired shape without damage to the material unless the specified heat ranges are exceeded.

You work a great deal with acrylic plastics that are synthetic and thermoplastic. The major use of transparent acrylic plastic is for aircraft canopies, windows, blisters, domes, and similar transparent enclosures. Three types of transparent plastics commonly used are acrylic plastics (also known as acrylate or methacrylate base plastics), cellulose acetate base plastics, and laminated acrylic plastics. Laminated acrylic plastic are made by bonding acrylic plastic with a vinyl resin interlayer, as shown in figure 1-1.

Acrylic plastics are used for enclosures because of high transparent properties, strength-to-weight ratio and forming ability. In addition to ease in fabrication and maintenance, plastics have other characteristics that make them better than glass for use in transparent enclosures. Plastics break in large dull-edged pieces; and they do not readily fatigue-crack from vibration. But on the other hand, although they are nonductors of electricity, they become highly electrostatic when polished.

Plastics do not possess the surface hardness of glass; so they are more easily scratched. Since scratches impair vision, be careful when servicing an aircraft to avoid damaging the transparent plastic parts. Specific procedures are discussed elsewhere in this chapter; some general rules to follow are:

a. Handle transparent plastic materials only with clean cotton gloves.

b. Never use harmful liquids as cleaning agents.

c. Follow rigidly the applicable instructions for fabrication, repair, installation, and maintenance.

d. Avoid operations which might tend to scratch or distort the plastic surface. Be careful not to scratch the plastic with finger rings or other sharp objects.

Exercises (800):

After each stratement, give the type or class of plastic described.

1. Class of plastic involving the use of nitric and acetic acids.

2. Class of plastic derived from ethylene, phenol, etc.

3. Oldest class of plastics.

4. Class of plastics which is both thermoplastic and thermosetting type.

5. When heated, a chemical change takes place in this type of plastic.

6. Type of plastic that has characteristics similar to those of sulphur and sealing wax.

7. Type of plastic that can be reheated and reshaped more than once.

8. Type of plastic that retains its shape until it becomes useless from deterioration, damage, etc.

801. Given MIL specifications or the results of plastic identification tests, determine the types of plastic identified.

Plastic used in transparent enclosures and combat type aircraft are generally acrylic. Cellulose acetate base plastics are used on training and observation aircraft, gliders, and helicopters. When available, acrylic plastics may be substituted for acetate base plastics; however, because of inferior strength qualities (poor resistance to weather, high degree of warpage, and poor transparency) cellulose acetate base plastics are

never substituted for acrylic plastics. Therefore, use utmost care in proper identification of original, replacement, or repair materials.

Specification Coding. Acrylic plastics are manufactured under the trade name of Lucite by the E. I. DuPont de Nemours and Company, Inc., and Plexiglas manufactured by the Rohm and Haas Company. Laminated acrylic plastics are made by bonding acrylic plastic with a vinyl resin interlayer but are not identified by specific trade names. Cellulose acetate base plastics are manufactured under the trade name of Fibestos, manufactured by the Monsanto Chemical Company; Lumarith, manufactured by the Celanse Corporation of America; and Plastacele, manufactured by the E. I. DuPont de Nemours and Company, Inc.

The plastic type, military specification and thickness in thousandths of an inch are clearly marked on the protective masking paper sheet found on both sides of the plastic sheet. The identity of transparent plastics used on aircraft is determined by the MIL specification number on the part. If the parts are not marked, the information in the following paragraphs will help you identify the material. Common MIL numbers and the type of material are as follows:

SPECIFICATION	*TYPE OF MATERIAL*
Monolithic	
Thermoplastic:	
MIL-P-6886	Regular Acrylic
MIL-P-5425	Heat-Resistant Acrylic
MIL-P-8184	Craze-Resistant Acrylic
Thermosetting:	
MIL-P-8257	Polyester
Laminated	
MIL-P-7524	Laminated MIL-P-5425
MIL-P-25374	Laminated MIL-P=8184

Identification Testing. The cellulose acetate plastics have a yellowish tint when viewed from the edge, and are softer than the acrylic plastics. Both acrylic and cellulose acetate base plastics have characteristic odors, especially when heated or burned. Burning a small sample and comparing its color to that of a known sample is a very reliable method of identification. The acrylic odor is fairly pleasant, but acetate is very repulsive. Acrylic plastic burns with a steady, clear flame. Acetate burns with a sputtering flame and dark smoke.

These plastics are also identified by the application of acetone and zinc chloride. Partially fill an eye dropper with a solution of acetone and apply it on an area of the plastic where it will not interfere with vision. Then blow on the area. If the plastic is acrylic, it will turn white; if it is acetate, it will soften but will not change color. A drop of zinc chloride placed on acetate base plastic will turn the plastic milky; but it will have no effect on acrylic plastic.

Transparent plastic enclosures and plate glass can be distinguished from each other by lightly tapping the material with a small blunt instrument. Plastic will resound with a dull or soft sound; in contrast, plate glass will resound with a metallic sound or ring. Very few of the transparent plastics are color clear when viewed from the edge. Specification MIL-P-6886 and MIL-P-5425 are practically clear. Specification MIL-P-8184 has a slight yellowish tint. Specification MIL-P-8257 has a bluish or blue-green tint.

Exercises (801):
In the place provided in front of each statement, indicate the type of plastic referred to in each statement by placing the letter of the specific type plastic listed in column 2.

Column 1	*Column 2*
___ 1. MIL-P-8257	a. Laminated Plastic
___ 2. MIL-P-6886	b. Heat-Resistant Acrylic
___ 3. MIL-P-8184	c. Regular Acrylic
___ 4. MIL-P-5425	d. Craze-Resistant Acrylic
___ 5. MIL-P-7524	e. Polyester Plastic
___ 6. Has a yellowish tint when viewed from the edge.	f. Acrylic Plastics
___ 7. Has a fairly pleasant odor when burned.	g. Cellulose Acetate Plastics
___ 8. Turns white when acetone is applied.	
___ 9. Turns milky when zinc chloride is applied.	
___ 10. Burns with a sputtering flame and gives off dark smoke.	

802. Given simulated circumstances, designate the proper procedure to employ when storing transparent plastics.

Storage Guidelines. We have learned that because acrylic plastics are thermoplastic, they soften and deform when heated sufficiently. To prevent the sheets from warping, keep them out of excessively warm storage places. Keep plastic sheets away from heating coils, radiators, hot water, and steampipes. Store them in a cool, dry location away from solvent fumes that prevail near spray and paint storage areas. Although sunlight is not harmful to plastics, keep the masked sheets out of the direct rays of the sun because sunlight may cause the masking paper adhesive to cling to the plastic and make its removal difficult.

Store plastic sheets (with the masking paper in place) in bins tilted at approximately a 10° angle from the vertical to prevent bucking. When storing vertically, place the sheets tightly so they will give support to each other. It is recommended that you store them in their original packing cases. When it is necessary to store sheets horizontally, take care to avoid getting chips and dirt between the sheets. Stack the sheets on

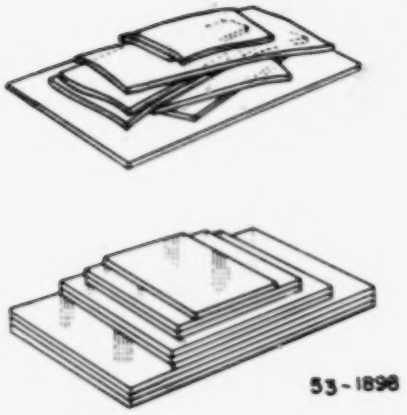

Figure 1-2. Horizontal storage of plastic sheets.

top of each other, in stacks no higher than 18 inches. Always place the smaller sheets on the larger ones to avoid unsupported overhang, as shown in figure 1-2. If sheets become bowed as a result of improper storage, straighten them by removing the masking paper, heating to forming temperature, placing them on a flat flannel-covered surface, and then allowing them to cool.

Store formed sections so they are amply supported and so there is no tendency for them to lose their shape. Simple frames or supports are often desirable to relieve strain or unusual pressure on curved parts. Keep formed parts covered with cloth or soft paper to protect them from dust. Also protect formed sections against temperatures higher than 120° Fahrenheit. Such temperatures cause them to lose their shape.

Surface Protection. When you find it necessary to remove masking paper from the plastic sheet during fabrication, remask the surface as soon as possible. You can replace the original paper on relatively flat parts or apply a protective coating on curved parts. When masking paper is difficult to remove, moisten the paper with aliphatic naphtha to loose the adhesive. Then immediately wash the surface with clear water. Remember, aliphatic naphtha is highly volatile and flammable. Always exercise extreme care when using this solvent. Never use tools when removing the masking paper because of the danger of scratching the surfaces.

After you remove masking paper from plastic sheets, check to be sure that no adhesives remain on the sheets. Use a piece of the removed masking paper to dab the areas until all adhesives are picked up. Hold the sticky side of the masking paper down as you dab.

Do not use gasoline, alcohol, kerosene, benzene, xylene, ketones (including acetone, carbon tetrachloride, fire extinguisher, or deicing fluids), lacquer thinners, aromatic hydrocarbons, ethers, glass-cleaning compounds, or other unapproved solvents on transparent plastic to remove masking paper or other foreign material; these soften or craze the plastic surface. Leave the masking paper on the plastic sheet as long as possible. Even though this paper is tough enough to protect the plastic from minor scratches, always exercise care when sliding large sheets over each other or across tables.

Certain protective coatings are available for formed parts. The coatings are applied by spraying. The minimum allowable thickness of the coating is 0.0009 inch. A layer of cheesecloth is embedded in the coating at the time of application to assist in removal of the masking spray. Coatings that remain on formed parts longer than 12 to 18 months become difficult to remove. Do not store transparent plastics or formed parts coated with this material outdoors where they will be subject to direct sun for longer than 4 months.

To remove spray masking from the plastic, peel it off. If the film is too thin to remove in a continuous film, apply a fresh coating of the compound, reinforced with a layer of cheesecloth, to obtain a thicker film and allow to dry. Soaking the coated part with clean cloths saturated with water at room temperature softens the film. You can then peel it off by hand. Do not use a solvent. Exercise care to avoid scratching the surface of the plastic. Do not use tools to remove the film because of the danger of scratching the plastic. Storage of transparent plastic sheets presents no special fire hazard, as they are slow burning.

Exercises (802):

1. If you were given ten sheets of transparent plastic, each a different size, how would you store them horizontally?

2. To avoid bowing transparent plastic sheets, how should you store them vertically?

3. If it were necessary to temporarily store a canopy within the Airframe Repair Shop, what procedures would you follow?

4. When formed parts are returned to base supply, what should you do to protect the plastic surfaces?

803. Specify true statements concerning the cleaning of transparent plastics and explain why the others are false.

Cleaning Rules. The steps that you will follow in cleaning plastic enclosure should become a permanent part of your procedure.

a. Always remove rings from your hands.

b. Rinse the plastic surface with plenty of water, using your bare hands to feel for and gently dislodge any dirt, sand, or mud.

c. Wash with mild soap and water. Be sure the water is free of harmful abrasives. Use a soft cloth, sponge, or chamois while washing but only to carry the soapy water to the plastic. Go over the surface with your bare hands to quickly detect and remove any remaining dirt before it scratches the plastic.

d. Dry with a damp clean chamois, a clean soft cloth, or soft tissue. Do not continue rubbing the transparent plastic after it is dry.

e. Clean with an approved cleaner for transparent plastics. If none of the approved cleaners are available, after soaping, rinse thoroughly with clear water (distilled water if possible) in a shaded area. Cleaning with water in the sunshine causes water spotting, which is objectionable to the pilot's vision.

f. Do not rub the plastic with a dry cloth. This not only scratches but builds up an electrostatic charge that attracts dust particles. If the surface becomes charged, pat or gently blot with a clean damp chamois to remove the charge as well as the dust.

g. Clean with an approved cleaner (Specification MIL-C-18767). Never use a coarse or rough cloth for polishing. Cheesecloth is not acceptable.

Interior Cleaning Procedures. The procedure for cleaning interior surfaces consists of three steps:

(1) Dust the plastic surface lightly with a clean, soft cloth saturated with clean water. Never use a dry cloth.

(2) Wipe carefully with a damp, soft cloth. Keep the cloth free from grit by rinsing it frequently with clean water.

(3) Clean with an approved cleaner.

Exterior Cleaning Procedures. Routine removal of traffic film and other operational soils (where abrasive polishing for scratch removal is not required) is done by the use of aqueous detergent solutions. The following materials are recommended: Wetting Agent, Synthetic, Nonionic, Specification MIL-D-16791; or Agent, Wetting, Alkyl Aryl Sulfonate, 40-percent active. Use these materials in concentrations of 2 to 3 ounces per gallon of water. Apply with soft cloths or photographic cellulose sponges that have been used for no other purpose. Polish and cleaner Specification MIL-C-18767 gives satisfactory results for most cleaning requirements.

After the surface has been cleaned and no scratches are present, apply one or two coatings of an automobile or furniture wax to produce a surface gloss. Such a waxy glass aids in protecting the plastic from abrasions.

Exercises (803):

1. Indicate which of the following statements is true or false, by placing the letter T or F in the space provided at the front of each statement.

____ a. Cleaning of transparent plastics should be done in bright sunlight to avoid soap film on the plastic.

____ b. Use a mild solution of soap and water to remove dust and dirt from transparent plastics.

____ c. Use a clean damp piece of cheesecloth to remove an electrostatic charge on transparent plastics.

____ d. Bare hands are used to gently dislodge any dirt, sand, or mud from transparent plastics.

____ e. Wetting agent type detergents are used to remove traffic film from transparent plastics.

____ f. A dry cloth can be used to clean transparent plastics only if the plastic is grounded and located in a shaded area.

2. Based on your answers to question one, state the correct procedures for all the false statements.

1-2. Inspection of Transparent Plastics and Laminated Glass Assemblies

804. Designate defects found during the inspection of laminated glass and plastic assemblies as either mechanical or material defects, and state the corrective action required.

Your inspection of plastic and glass assemblies requires checking for scratches, nicks (chipping), cracks, bubbles, delaminations, fractures, crazing, and optical distortion. You visually inspect to determine if the assembly meets surface and optical requirements as outlined in the applicable technical order. The acceptable imperfection limits are given for windshields, side panels, canopies, etc. After reworking the assemblies or parts, inspect them for optical distortion, for thickness of glass, and for compliance with the applicable technical order. You must also exercise good judgment when you inspect.

Mechanical Defects. Scratches are the most common defects in plastics. The length, depth, number of them in a given area, and location determine whether to replace the enclosure or plastic panel. Scratches are acceptable if they can be sanded or buffed out without reducing the panel thickness to less than prescribed (for visual concerns) by the applicable technical order. Nicks (chipping) are similar to

scratches; these may be removed by sanding. However, this is not done if the reoval of the material reduces the panel thickness to less than prescribed by the applicable technical order, or if the removal impairs vision.

Cracks and fractures are not acceptable in plastic enclosures. However, a temporary repair for a crack is given in TO-1-1A-12, *Fabrication, Maintenance, and Repair of Transparent Plastics.* Use this repair only under extreme emergency conditions. Surface imperfections (orange peel, pits, pimples, and mark-off) caused by lint impression are acceptable, provided these conditions do not impair vision or cause localized distortion.

Material Defects. Delaminations are found in glass and laminated plastics. This is a separation of the outer or inner face ply and the vinyl core. The strength of the window is not seriously affected by delamination, but visibility can be reduced and window heating impaired because of damaged conductive coating. When either visibility or window heating is impaired, the delaminated window is replaced. Delaminated windows are sometimes confused with chipped windows, which are a cause for immediate removal. To avoid confusion, you can identify a delaminated window by the following characteristics of the material:

a. The delaminated area is smooth in appearance in both direct and indirect light.

b. Visual distortion through the delaminated area is slight except along the edges of the delaminated area.

c. Delamination generally begins near the edge of the glass and spreads inward toward the center and along the edge.

d. Unless viewed at an angle, the delaminated area may be difficult to detect.

e. A milky (cloudy) appearance anywhere around the edge of either the inner or outer glass is an indication of actual or imminent delamination as a result of moisture penetration.

f. Large bubbles between layers or plies of glass are found mostly in laminated plastics. They are acceptable if well scattered, provided they do not impair vision. The applicable technical order gives you the acceptable number, diameter, and spacing for each area on the enclosures, panels, and windows.

Chips on the laminated surface of the glass are layers or flakes of glass broken from the surface by excessive stresses in areas where the strength of the bond between the core and the glass is greater than the surface strength of the glass. Chipping seriously weakens the glass pane in which it occurs and may damage the conductive coating. Any window in which the inner pane is chipped or window heating is impaired is replaced. A chipped window is identified as follows:

a. A chipped area has a rough or grained appearance readily detectable in reflected light.

b. White powdered glass is often seen in a chipped area.

c. Visibility through the chipped area is poor and badly distorted.

d. A chip may occur anywhere on the inner surface of a windowpane. It usually starts at a small point of origin and progresses outward from this point. Again check the applicable technical order for the acceptable number of separations, length, and width of each chip.

Exercises (804):

1. Identify each of the following defects in laminated glass or plastic assemblies as either a mechanical defect or material defect by placing the appropriate type in the space provided.
   _____ a. Scratches
   _____ b. Nicks
   _____ c. Bubbles
   _____ d. Delamination
   _____ e. Cracks
   _____ f. Chips on the laminated surface.

2. Specify the corrective action for each of the defects listed in question 1 above.

805. Specify the causes of specific defects in plastic surfaces.

Crazing. Crazing is a pattern or area of tiny fissures or splits in the plastic, resembling the cracking of glaze in pottery or surface splits on weathered wood. Crazing having fissures of discernible width must be considered as cracks. The edges of crazing fissures cause undesirable highlights and reflections during night flying or during daylight flights especially when flying directly into the sun. Crazing is a warning that the material has been weakened physically by the presence of solvents or of concentrated and locked-in stresses that have been partially or completely relieved.

Crazing fissures are difficult to detect, since they are approximately perpendicular to the surface, very narrow, and usually not over 0.01 inch in depth. They can be best seen by moving the piece to be inspected under an overhanding light and looking at the surface of the plastic in front of a dark background. You can do this on an aircraft by using a light (flashlight or extension light) while looking on the outside surface and having a dark surface (cardboard or other black paper) on the underside. The minute fissures are both an optical and a machanical defect because there is a separation of material.

If the crazing is in a random pattern, it can usually be ascribed to the action of solvents or solvent vapors. If the crazing is approximately parallel, the usual cause is a directional stress set up by cold-forming, excessive loading, improper installation, improper machining, or a combination of these. Once a part has crazed, neither the optical nor the mechanical defect can be removed. Consequently, the preventive measures are as follows:

a. Forming at sufficiently high temperature.

b. Proper control of sawing, drilling, milling, routing, sanding, polishing, and other machining operations.

c. Care in application of an approved cement.

d. Careful installation in an approved manner.

e. Use of approved cleaners only.

f. Keeping acrylic parts away from solvents or solvent forms.

g. Proper annealing of fabricated parts is the most effective single preventive measure against crazing.

Scattered areas of light crazing are allowable in the canopy glass, windows, and other enclosures. They must be within the established optical requirements for the individual aircraft and never in an area that would impair vision.

Distortion. Visual distortion is a visual imperfection in acrylic caused by the use of harmful cleaning materials or chemical vapors, improper cleaning practices, excessive heat or accumulation of surface damage through use. Distortion can also be caused by improper restoration (polishing) methods and/or materials used during attempts to repair damages, such as scratches, pits, and chipping. A critical examination should be made to detect visual distortion after the completion of a scratch removal operation.

Excellent lighting is imperative to recognize distortion, and bright sunlight should be used when possible. A check for distortion of acrylic plastic panels may be made by viewing horizontal and vertical lines through the panel at a distance of at least 30 feet from the panel. A grid manufactured for this purpose or the crossed frame of a window, will readily detect distortion in any direction. If the plastic panel has been removed, place it on a table and view the grid while simulating the position and movements of a pilot in the aircraft. The horizontal and vertical lines should retain their shape and position during all movements. A straight object should not curve or break pattern.

For several reasons, distortion in plastic may occur. A deep scratch, chip or pit, if not completely removed, will cause severe distortion in one location. If the distortion is localized and severe, it is probably due to a surface defect or to not removing enough plastic to blend a damaged area during a restoration attempt. Surface distortion takes the form of many very slight lines, even causing visual imperfections as objectionable as one severe line or spot of distortion. Surface distortion can result from manufacturing defects, minute scratches, improper handling and cleaning methods, or abrasive marks from an incomplete restoration attempt.

Exercises (805):
In the space provided after each described defect, write-in the cause of the specific defect.

1. Defect–Crazing is in a random pattern.
   Cause–

2. Defect–Crazing is approximately parallel.
   Cause–

3. Defect–Severe distortion in one location.
   Cause–

4. Defect–Distortion is localized and severe.
   Cause–

1-3. Maintenance of Transparent Plastics

To properly maintain plastic structures, you must keep them clean and free of damage. Fabrication, repair, and maintenance procedures differ with the type plastic used and the function of the aircraft. Procedures set forth in this section are those processes that can be accomplished in the shortest possible time with the simplest equipment. Any damaged plastic part should be replaced. Temporary repairs are recommended for use ONLY under emergency conditions. Parts that have been temporarily patched, should be replaced as soon as possible. Even a perfectly patched part is neither optically nor structurally equal to a new part.

806. Given simulated work circumstances involving the cutting and drilling of acrylic plastics, state the correct procedure to use.

General Guidelines. The fabrication properties of acrylic plastics are generally compared to those of wood or soft metal. Good craftmanship, suitable equipment, and proper design are just as necessary to successful fabrication of acrylic parts as they are to good workmanship in wood. Light to medium woodworking equipment procedures satisfactory results; however, heavy-duty machines, which are less apt to vibrate, are even better. General rules of machining apply; and once you get the "feel" of the plastic, you

can do clean, accurate work. Keep your tools sharp and free from nicks and burrs. Since these plastics soften or become gummy when they are hot, keep frictional heat from building up or dissipate the heat by the application of a lubricant. Water or a mild soap solution makes a good lubricant for acrylic plastics and, if applied to a drill or saw, prevents burning or clogging. If the masking paper is still intact, be careful that contact of the lubricant with the masking paper is minimal. Moisture will cause a loss of strength in the masking paper, and removal is difficult. To prevent scratching during machining and forming operations, keep plastics covered either by applying masking tape or by leaving intact the masking paper applied by the manufacturer.

Cutting. Where extreme accuracy is not required, laying out the work may be accomplished by penciling and cutting lines directly on the masking paper. For close tolerances, however, it is advisable to scribe layout lines directly on the surface of the plastic. Use straightedges or layout templates according to the requirements of the job. If the masking paper is removed before scribing, replace it again to within 1/4 inch of the scribed markings before the piece is cut.

Layout templates may be of plastic sheeting to which suitable handles can be cemented. Round the sharp edges and smooth the rough spots. In the case of metal templates, it is good practice to cement thin flannel over the contact surfaces.

To cut plastic sheets, use ordinary hand, hack, band, circular, or jigsaws. Thin sheets may be cut by scribing a deep line, then breaking along the line. Hand and hack saw teeth should have very little set and should be fine enough so that at least two teeth are cutting at all times. To cut 1/8-inch stock, for example, you use a saw blade having a minimum of 16 teeth per inch. Band saws dissipate heat more readily than do circular saws. Accordingly, they operate at lower temperatures and are better suited for cutting thick plastic sheets. Fine teeth with no set produce a smooth cut if the work if fed slowly. If curves are to be cut, set is necessary even though narrow blades are used. Use jig saws for cutting curves with small radii and band saws for larger curves. Adjust the blade guides as close to the work as possible so that control "weave" is kept to a minimum. Metal cutting blades have been found best for cutting plastics.

The feed for all types of hand and power saws, cannot be accurately stated—it must be learned from experience—but in general, it is relatively slow. Moderate smoking and smearing at the edges are indications of too rapid a feed to too much pressure. A good practice for obtaining smooth edges at the exit end of a cut is to slow down the rate of feeding as the saw blade leaves the cut.

Drilling. To drill holes use an end mill or an ordinary twist drill with the point ground, as shown in figure 1-3. Use a moderate drill speed, feed slowly, and use light pressure to avoid "grabbing," especially as the drill breaks through on the other side of the piece of plastic. During the drilling operation, hold the work securely by clamps or other fixtures provided. Portable hand drills may be used in conjunction with special jigs, however, drill presses produce better drilling results.

As in the case of sawing, the feeding rate is a matter of experiment and judgment. Too fast a feed will cause chipping and strain cracks. Proper feed is indicated by smooth, continuous spiral chips or ribbons. Avoid overheating by decreasing the rate of feed as the depth of cut is increased.

Use drill lubricants because they aid in chip removal, dissipate heat, and improve the surface finish of the hole. The best lubricant for drilling acrylics is a thin, mild soap solution. It is possible to drill shallow holes satisfactorily without the use of a lubricant if you feed the stock slowly to avoid overheating. Lifting the drill from the work frequently to let it air-cool is good practice.

The best results can be obtained when drilling plastic if you remember the following:

a. Use twist drills with slow-spiral polished flutes. The flutes should be as wide as possible.

b. The twist drill should be carefully ground free of nicks and burrs which would effect the surface finish.

c. It is particularly important that the cutting edge of the twist drill be dubbed off to zero rake angle, as shown in figure 1-3.

d. The length of the cutting edges (and hence the width of the chip) may be reduced by increasing the included angle of the twist drill.

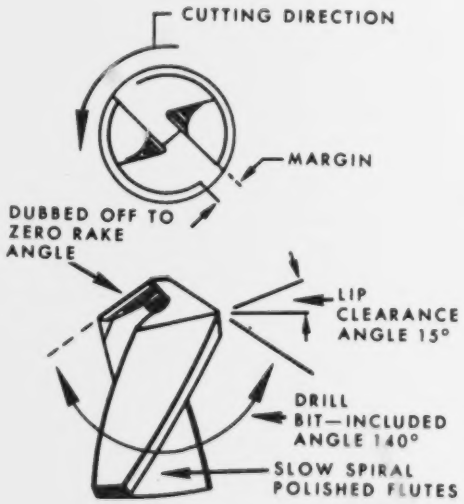

Figure 1-3. Recommended twist drill for plastics.

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Exercises (806):

1. If the masking tape on a plastic part was removed for scribing, cut lines, what must you do before actually cutting the port?

2. To prevent blade weave when cutting plastic using a jig saw, what should you do?

3. When using a band saw to cut plastic stock, what factor should influence your blade selection?

4. What corrective action would you take, when cutting plastic stock with a band saw, if moderate smoothing and smearing of the edges occurs?

5. What procedure is indicated when grabbing of the twist drill occurs as it breaks through the backside of a plastic sheet?

6. For drilling deep holes in plastic structure, what procedures should you use?

807. Given data related to forming transparent acrylic plastics, designate the appropriate work procedure or specification.

Cold Forming. Transparent plastics may be cold formed (single curvature) if the material is thin and the radius of curvature to which it is cold-bent is at least 180 times the thickness of the sheet. For example, an 18-inch length of transparent plastic 0.250-inch thick should not be deflected more than 3/4 inch. Cold-bending beyond these limits may eventually result in tiny fissures (crazing) appearing on the surface of the plastic because of stresses being imposed beyond those recommended for continuous loading.

Hot Forming. Transparent acrylic plastics become soft and pliable when heated to their respective forming temperatures. They can then be formed to almost any shape; and, on cooling, the material retains the exact shape to which it was formed, except for a small contraction. It is not desirable to cold-form compound curvature transparent plastics (that is, to spring them into a curved frame without heating). For hot-forming, transparent plastics should be maintained at the proper temperature as recommended in TO 1-1A-12, *Fabrication, Maintenance, Repair of Transparent Plastics*.

Use an oven for softening transparent plastic sheets prior to forming. A circulating air oven is preferable. A fan or other means of forced circulation is employed to maintain even heat through the oven. The oven must be capable of operating over a range of 49° to 190° centigrade (120° F. to 374° F.) For uniform heating, it is best for you to hand the sheets of plastic vertically, using an overhead monorail mounted in the roof of the oven and equipped with a spring channel or a series of clips for grappling the plastic sheet.

For small pieces that are inconvenient to handle and for pieces cut with insufficient trim to which the clips or channels can be clamped, shelves or drawers must be provided. Shelves covered with soft felt or flannel are of openwork construction to assure maximum circulation or air around the sheet for uniform heating.

Be sure the air distribution is uniform over the entire surface. Such an arrangement necessitates filtration of any fresh air which is admitted to the over. In an emergency, any available oven (such as a kitchen baking oven) may be used. Wear white cotton gloves while handling the unmasked sheeting. Ovens are used also for annealing plastic enclosures before and after cementing and after matching or fabrication.

Sometimes other means are employed for heating transparent plastic prior to forming. For example, infrared lamps may be used. They are usually arranged on 7- to 8-inch centers in a bank sufficiently large to cover the maximum size sheet involved. The sheeting should be placed approximately 18 inches from the face of the lamps to obtain even distribution of the radiant heat. In general, any method other than oven heating is undesirable and should be used only in emergencies. Do not use hot water or direct steam to heat transparent plastic because it may cause the plastic to become milky or cloudy.

Allow sufficient time for the entire sheet to heat to the forming temperature. Prior to heating, remove all masking paper and adhesive from the plastic sheet. If the plastic sheets are dusty or dirty, wash and rinse them well with clear water. Dry the sheets thoroughly by blotting with soft absorbent paper. Thin material must be heated to a higher temperature than thick material because it cools more rapidly.

Heating the plastic above the temperature range for the given grade of acrylic type plastic will cause bubbling on the surface of modified plastic material (Specification MIL-P-8184). In addition, overheating may impair some of the physical properties of the material before bubbling is apparent. When handling hot transparent plastic sheets, be careful to avoid fingermarking or otherwise damaging the soft surface. The transparent plastic blanks should be slightly larger than the required finished size to provide an edge that can be handled freely without danger of scarring the surface of the material of the finished part. After the material has been formed, allow it to cool

slowly. Cooling should be uniform over the entire surface to reduce internal stress.

Exercises (807):

1. When it is necessary to cold-form transparent plastic sheets, using a cornice brake, how do you determine the correct bend radius to use?

2. When pre-heating of acrylic plastic prior to forming, what type of oven should you use?

3. If you need to pre-heat acrylic plastic prior to forming using heating lamps, how far from the surface should they be positioned and in what arrangement?

4. When hot forming acrylic plastics, how can you avoid fingermarking or other damage to the soft surface of the plastic?

808. Differentiate between the types of adhesives and methods of cementing acrylic plastics by matching descriptive statements with the items they best describe.

Adhesives. With care and proper procedures, it is possible to obtain a cemented joint that approximates the original acrylic plastic strength. The type of acrylic plastic being cemented determines the type of adhesive to be used. Acrylic monomer base adhesive, Military Specification MIL–8576, is used when cementing regular acrylic plastic, Military Specification MIL–P–6886, and heat-resistant acrylic plastic, Military Specification MIL–P–5425. Acrylic monomer and polymer base adhesive, Military Specification MIL–A–25055, is used when cementing craze resistant acrylic plastic, Military Specification MIL–P–8184. NOTE: For polyester type plastics, MIL–P–8257, an epoxy type of adhesive with curing agent A is used.

MIL–A–8576 adhesive. The adhesive conforming to military specification MIL–A–8576 is a mixture of a polymerizable ingredient (monomer) and a solvent. A catalyst is furnished as a separate ingredient and must be added to the mixture before using in accordance with the manufacturer's instructions. The adhesive has a shelf life of at least one year if the catalyst is not added and the container is kept tightly closed. After the catalyst is added, the following shelf lifetime applies at the given temperature:

TEMPERATURE	SHELF LIFE
50° C. (122° F.)	20 hours
40° C. (104° F.)	3½ days
25° C. (77° F.)	45 days
5° C. (41° F.)	5 months

In use, the solvent evaporates causing the adhesive to thicken. If the shelf life has not been exceeded, methylene chloride may be added to keep the proportion of monomer to solvent correct. Methylene chloride is toxic if its vapors are inhaled over a period of time, thus, provide adequate ventilation when working with this adhesive.

In emergencies when MIL–A–8576 adhesive is not available, methylene chloride may be used. It is a more active solvent than the cement and shorter soak periods should be used. Also, it is more conducive to blushing or whitening of a joint.

MIL–A–25055 adhesive. The adhesive conforming to military specification MIL–A–25055 is a viscous solution of methyl methacrylate monomer. To this mixture is added a catalyst (supplied in capsules) and a promoter, or liquid accelerator. Do not mix the catalyst directly with the promoter material since a rapid decomposition reaction will result. The shelf life of the adhesive varies with the storage temperature and whether or not the catalyst has been added. When the adhesive has been mixed with the promoter and catalyst, it has practically no useful life at high temperature and only approximately 30 minutes shelf life at 73° F. (23° C).

Acrylic monomer and polymer base adhesives, Military Specification MIL–A–25055, contains a volatile liquid that may prove toxic if the vapor is inhaled for extreme periods. Use only with adequate ventilation. If accidentally spilled on the hands or skin, remove the adhesive immediately by dissolving with solvent (ethyl or isopropyl alcohol) followed by washing with soap and water. When overexposure symptoms of drowsiness, dizziness, and nausea appear, wrap the patient in blankets, provide plenty of fresh air, and obtain medical assistance.

Acrylic monomer and polymer base adhesive, Military Specification MIL–A–25055, should be kept out of sunlight and away from sources of heat that will accelerate the curing rate of the adhesive. Do not dispose of the adhesive container until the adhesive has set and the container is cool. Mix the catalyst and promoter with adhesive in accordance with the adhesive manufacturer's instruction sheet.

Methods of Cementing. There are three different methods used in cementing of acrylic plastics—soak method, glue method, and direct application method. The type of adhesive to be used in cementing helps to determine the appropriate method. When using acrylic monomer base adhesives, Military Specification MIL–A–8576, use the soak or glue method. When using acrylic monomer or polymer base adhesive, Military Specification MIL–A–25055, use the direct application method.

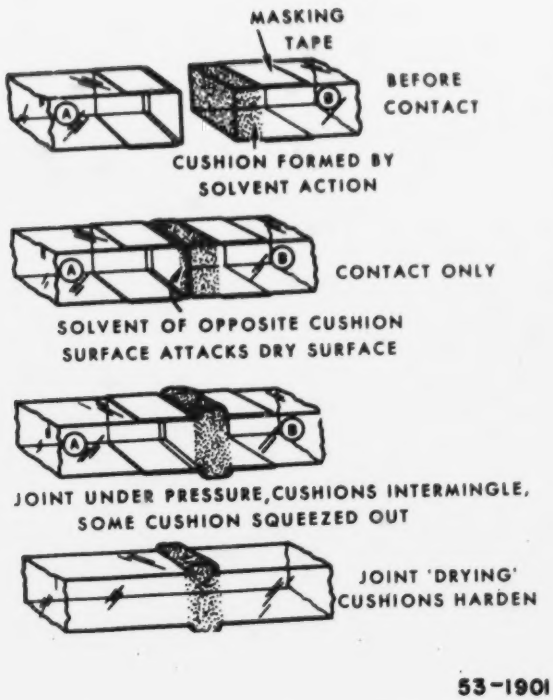

MASKING TAPE
BEFORE CONTACT
CUSHION FORMED BY SOLVENT ACTION
CONTACT ONLY
SOLVENT OF OPPOSITE CUSHION SURFACE ATTACKS DRY SURFACE
JOINT UNDER PRESSURE, CUSHIONS INTERMINGLE, SOME CUSHION SQUEEZED OUT
JOINT 'DRYING' CUSHIONS HARDEN
53-1901

Figure 1-4. Soak method of cementing plastics.

Soak method. The most common method of cementing regular acrylic plastic, Military Specification MIL-P-6886, and heat resistant acrylic plastic, Military Specification MIL-P-5425, is the soak method. This consists of placing one of the two pieces to be cemented into a soak tray filled with acrylic monomer base adhesive, Military Specification MIL-A-8576, until a sufficient cushion is formed. Although no arbitrary soaking time can be set, regular acrylic plastic soaked an average of about 10 minutes forms a cushion deep enough to take care of any discrepancies in the fitting of the two parts. In cementing heat-resistant acrylic plastic, a slightly longer time may be required. Immediately after soaking time has elapsed, the piece soaked in the adhesive is pressed against the opposite dry surface. The excess cement forms a second cushion that is shallow, but enough to permit thorough internmingling of the two surface as shown in figure 1-4.

Glue method. The glue method is also used for cementing regular acrylic plastic, Military Specification MIL-P-6886, and heat-resistant acrylic plastic, Military Specification MIL-P-5425. When performing this type repair, clear transparent acrylic plastic shavings of the same type as the transparent acrylic plastic being cemented are dissolved in acrylic monomer base adhesive, Military Specification MIL-A-8576, to give it a thick, syrupy consistency so that it can be applied like glue. This viscous cement, however, works on exactly the same principles as a soak cement; for example, the excess adhesive softens and swells both surfaces, permitting an intermingling of the cushions and the formation of a cohesive bond as shown in figure 1-5.

Direct application method. When cementing craze resistant acrylic plastic, Military Specification MIL-P-8184, use the direct application method. When using this method, apply acrylic monomer and polymer base adhesive, Military Specification MIL-A-25055, to either one or both surfaces and assemble immediately. The parts should be held together in a jig while the cement cures. This method of cementing does not form a cushion as does the two methods previously discussed. The joint may be handled after being subjected to a temperature of 70° F. (21° C.), or higher, for 4 hours, but should be allowed to harden for 25 hours at room temperature or 4 hours at 150° F. (66° C.) before further machining or forming.

The surface of Specification MIL-P-8184 plastic material to be cemented must be sanded or otherwise roughened before application of the adhesive. For best results, use 240–400 grit sandpaper. Laboratory tests show that sanding of the surfaces to be cemented is essential to the development of adequate joint strength. It is very important that the parts fit closely before cementing. It should not be necessary to flex either piece of a joint more than a few thousandths of an inch to make the two pieces come in complete contact. This adhesive does not develop a "cushion" on

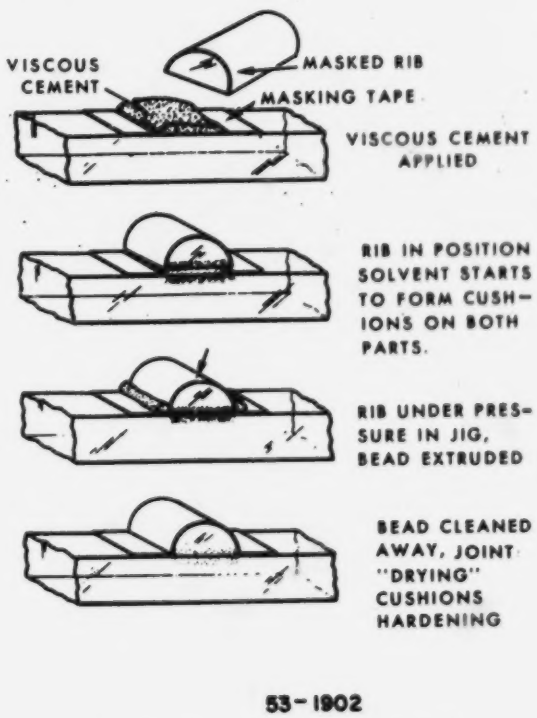

VISCOUS CEMENT
MASKED RIB
MASKING TAPE
VISCOUS CEMENT APPLIED
RIB IN POSITION SOLVENT STARTS TO FORM CUSHIONS ON BOTH PARTS.
RIB UNDER PRESSURE IN JIG, BEAD EXTRUDED
BEAD CLEANED AWAY, JOINT "DRYING" CUSHIONS HARDENING
53-1902

Figure 1-5. Glue method of cementing plastics.

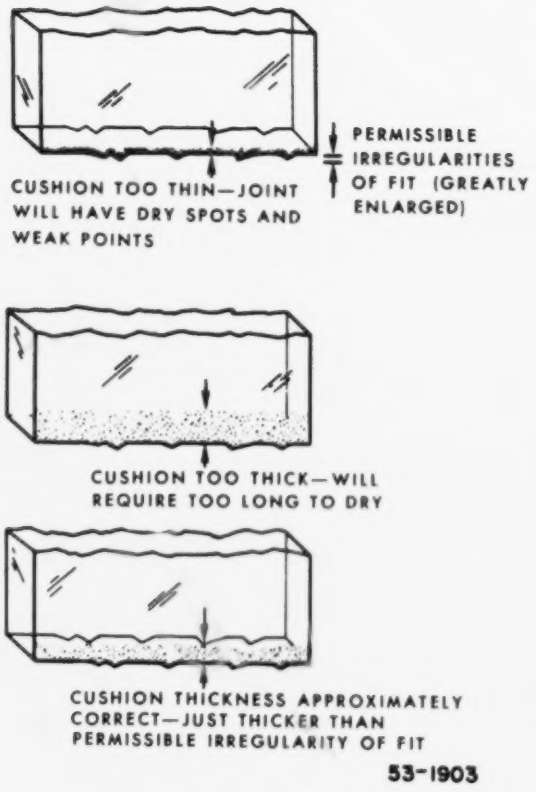

PERMISSIBLE IRREGULARITIES OF FIT (GREATLY ENLARGED)
CUSHION TOO THIN—JOINT WILL HAVE DRY SPOTS AND WEAK POINTS
CUSHION TOO THICK—WILL REQUIRE TOO LONG TO DRY
CUSHION THICKNESS APPROXIMATELY CORRECT—JUST THICKER THAN PERMISSIBLE IRREGULARITY OF FIT
53-1903

Figure 1-6. Proper cushion thickness.

Specification MIL-P-8184 plastic as does the adhesive used for material Specification MIL-P-5425 and MIL-P-6886.

Exercises (808):
Match the items given in column 2 with the items in column 1 by placing the number or numbers of the items in column 2, in the space provided in front of each item in column 1.

Column 1

1. ____ Used to cement MIL-P-6886 acrylic plastic.
2. ____ Requires an epoxy type adhesive.
3. ____ Used to cement MIL-P-8184 acrylic plastic.
4. ____ An acrylic monomer and polymer base adhesive.
5. ____ An acrylic monomer base adhesive.
6. ____ Soak Method of cementing is used for this plastic/s.
7. ____ Glue Method of cementing is used for this plastic/s.
8. ____ Direct method of cementing is used for this plastic/s.

Column 2

(1) MIL-A-8576 Adhesive
(2) MIL-A-25055 Adhesive
(3) MIL-P-6886 Acrylic Plastic
(4) MIL-P-5425 Acrylic Plastic
(5) MIL-P-8184 Acrylic Plastic
(6) MIL-P-8257 Polyester type Plastic.

809. Explain how to carry out, or the reason for, specific procedures associated with cementing acrylic plastics.

Selecting the correct adhesive to use with the right type plastic being cemented is only the first step in obtaining a strong plastic bond. Procedures such as, soaking, fitting, masking, and assembling must be carefully followed to insure a proper bonded joint.

Soaking. The function of the cushion formed by acrylic monomer base adhesive, Military Specification MIL-A-8576, when cementing regular acrylic plastic, Military Specification MIL-P-6886, or heat resistant acrylic plastic, Military Specification MIL-P-5425, is only to permit intermingling of the two surfaces to be bonded. The adhesive on the cushion surface, not the cushion itself, is the bonding agent. The cushion should be only large enough to assure intimate contact as shown in figure 1-6.

Fitting. For a satisfactory joint, the two pieces to be cemented should fit accurately. It is preferable to cement flat surfaces rather than curved. It is, therefore, advisable to rout or sand curved sections to present flat surfaces before cementing. Where two curved surfaces must be cemented, as in an overlap joint of two curved sections, the curves on both should have the same radius. Bond cemented joints firmly over at least 90 percent of the joint surfaces within any joint. The remaining 10 percent may have bubbles and/or dry spots, unless otherwise noted on applicable drawings. The two surfaces should have a fairly smooth finish. It is not necessary that you polish the surface, but at least sand them smooth.

Masking. To confine the softening action of the adhesive to the area of the joint, it is necessary to mask the surrounding acrylic plastic. For this purpose, use a pressure-sensitive tape, impervious to the action of the adhesive. Cellophane tape, fiber tape number 670 or scotch tape should be used. It is important that the tape be well applied, particularly at the edge. and that enough overlap (approximately 1/4 inch) be allowed so that the adhesive does not seep under the edge and attack the acrylic plastic to be protected. Be sure that the edges are firmly attached and that there are no air bubbles beneath the tape. Since the application of successive strips of tape is often time consuming, it is sometimes preferable to mask a complicated or curved part by coating it with a plasticized gelatin solution. NOTE: The special paper tapes used for masking against the types of solvent adhesives, inhibit the polymerization of adhesive Specification MIL-A-25055 and should not be used with this material.

Assembling. The interval between the soak for regular acrylic plastic (Military Specification MIL-P-6886) or heat-resistant acrylic plastic (Military Specification MIL-P-5425) and the direct application for craze resistant acrylic plastic (Military Specification MIL-P-8184) and the assembly of the

joint is perhaps the most critical of the entire cementing operation. Since these liquid adhesives evaporate quickly, assemble the joint as quickly as possible. If the cushion is allowed to dry, or if the joint is wiped free of the adhesive before the joint is closed, the joint may break open or it may lack the required strength when the pressure is removed. The soak tank used in cementing regular acrylic plastic and heat-resistant acrylic plastic should be near the cementing operation. Jigs should be arranged so that the operator can assemble the two pieces accurately with a minimun of elapsed time. It is important to allow a slight interval between the time the two pieces are placed in contact and the time pressure is applied. Ordinarily, 15 to 30 seconds is a sufficient interval.

In many cases, the success of a cementing job depends on the design of the jig holding the two pieces in place until the joint is set. The jig should keep the two pieces firmly together, but should not force either of them out of shape. The pressure should, first, be great enough to squeeze all air bubbles from the joint and assure thorough intermingling of the cushions; second, it should be applied evenly all along the joint to avoid stress concentrations at any point; and third, it should be maintained to compensate for the shrinkage that takes place in the joint during setting or hardening. Since the swelling action of the adhesive in forming a cushion causes an increase in volume, the cushion will shrink as the adhesive evaporates. Avoid excessive pressure in order to prevent localized stress concentrations that cause crazing.

When placing the assembly in a jig, and at intervals thereafter, it is advisable to examine the joint carefully. If slipping is noted before the joint has set, the pressure can still be readjusted or the job taken apart for reassembly. After the assembly has been locked in its jig, any excess adhesive and cushion that has extruded from the joint should be removed by scraping the excess onto the masking and then removing the tape.

If the assembly is constructed of regular acrylic plastic, Military Specification MIL-P-6886, or heat-resistant acrylic plastic, Military Specification MIL-P-5425, the assembly should be allowed to remain in its jig at least 4 hours; and an additional 4 hours should elapse before the assembly is subjected to handling or heat treatment. If the assembly is constructed or craze-resistant acrylic plastic, Military Specification MIL-P-8184, the assembly should be allowed to remain in its jig for 4 hours at a temperature of 70° F. (21° C.) or higher; and an additional 25 hours at room temperature or 4 hours at 150° F. (66° C.) should elapse before further machining or forming. NOTE: Since adhesive vapor, as well as the adhesive itself, can cause crazing, assemblies with inclosed spaces should be ventilated adequately.

Exercises (809):

1. When cementing acrylic plastics using the soaking method, why is it necessary to form a cushion along the bond line?

2. Why should you rout or sand flat, if permissible, a curved plastic surface that is to be cemented?

3. How is a cemented plastic joint inspected?

4. How should you confine the softening action of the adhesive to the area of the joint?

5. How is a cemented plastic joint cured?

6. Why must pressure be applied all along the joint being cemented?

810. Specify procedures and precautions to be followed in heat-treating and annealing acrylic plastics.

Heat-Treating. After regular plastic, Military Specification MIL-P-6886, or heat-resistant acrylic plastic, Military Specification MIL-P-5425, are assembled, they should be cured and heat treated. A solvent joint never dries completely; that is, it will never become entirely free of the solvent. If the temperature is raised, the cushion will enlarge slowly until a new equilibrium is reached. Upon cooling, the cushion will be larger and correspondingly harder, as it contains less solvent per unit of volume. Heating a solvent joint long enough to expand its cushion, therefore, will produce a much stronger joint.

Heat treating of cemented joints must be undertaken with caution. Heat first activates the adhesive, which softens the cushion. The cushion then slowly expands as the adhesive penetrates the material. In heat treating, it is important that the temperature does not approach the softening point of transparent acrylic plastics.

For regular acrylic plastic, Military Specification MIL-P-6886, a suitable temperature would consist of 48 hours at 122° F. (50° C.); for heat-resistant acrylic plastic, Military Specification MIL-P-5425, a

suitable temperature would be 48 hours at 150° F. (66° C.). Should these temperatures cause undue dimensional changes in intricate assemblies, it may be desirable to reduce the heat-treating temperature to 91° F. (33° C.) and increase the length of time of heat treatment to 72 hours.

Heat treatment offers an additional advantage if the adhesive contains monomer, as does acrylic monomer base adhesive, Military Specification MIL-A-8576. The same process (polymerization) that causes the liquid to become solid takes places when the joint is heated. It is important that the joint be thoroughly hardened before machining, sanding, or polishing to remove the bead.

Annealing. To prevent crazing during bonding and cementing, transparent plastic must be annealed following forming or machining. Annealing should take place not more than 24 hours prior to cementing. Annealing of plastics consists of prolonged heating at an elevated temperature followed by slow cooling. This results in a plastic of greater dimensional stability and greater resistance to crazing. In order to obtain these benefits, it is necessary to anneal after all other fabrication procedures, including polishing, are completed. The annealing also materially increases the strength of a cemented joint. Tables listed in TO 1-1A-12 gives the recommended heating times for annealing various thickness of transparent plastic sheet.

The annealing temperature for acrylic plastic, material Specification MIL-P-8257, is 60° centigrade (140° F.) for a period of 11 hours. The parts can be cooled by turning off the oven heat or by removing them to a place where they will be exposed to room temperature in still air. After elevated temperature annealing, the part must be cooled at an even rate. The rate of cooling must be slower for thick sections than for thin ones.

Exercises (810):

1. What precaution must be observed when heat-treating plastic parts?

2. What is the recommended heat-treating time and temperature for regular acrylic plastic?

3. When heat-treating intricate plastic parts, what can you do to reduce the possibility of undue dimensional changes taking place during the heat-treating process?

4. How long should you wait after forming plastic parts before annealing?

5. How can plastic, that have been annealed, be cooled?

811. Identify characteristics and work procedures associated with laminated plastic structures.

Characteristics. Laminated plastic enclosures are made by bonding two layers of monolithic transparent sheets together with a soft plastic inner layer. They are installed in pressurized aircraft because of their superior shatter resistance and greater resistance to explosive decompression as compared to monolithic plastic enclosures.

The inner layer material that has shown the most desirable balance of physical properties is polyvinyl-butyral. This material is manufactured in sheets of 0.015 to 0.20 inch in thickness. Several layers of this material are used to build up the thickness required for the inner layer.

Generally, the two transparent plastic outer layers are of the same thickness (balanced laminates); however, some laminates have been made in which the two outer layers were of unequal thickness (unbalanced laminates). At present, three types of approved transparent plastic materials are available for laminated materials. These are heat-resistant cast acrylic, Specification MIL-P-5425; acrylic sheet, modified, Specification MIL-P-8184; and cast polyester' sheet, Specification MIL-P-8275.

Working Procedures. The successful fabrication of laminated transparent plastic is more difficult than similar operations with monolithic transparent plastics because of the different characteristics of the plastic vinyl layers. The forming temperatures that have been found the most desirable for the various plastics are not compatible with the properties of the inner layer material. Bubbles may form in the inner layer that will not disappear when the material is cooled. The inner layer should not be subjected to temperature above 165° Fahrenheit.

One method, called flash heating, is to heat the material quickly so that the face sheets will be brought to forming temperature, formed, and cooled before the inner layer has reached its critical temperature.

The second method, called controlled forming, is to use a carefully controlled temperature just under the critical temperature of the inner layer. It is by no means the ideal forming temperature, and it results in a semicold-formed part that may incorporate an unusually high level of residual stress. These stresses,

like any other imposed on the transparent plastic, may not be high enough to cause failures, but they do increase the susceptibility of the part to crazing. To decrease the crazing tendency, anneal the formed part at a temperature of approximately 140° to 165° Fahrenheit for a period of time sufficient to allow the residual stresses to be relieved.

The same tools and equipment recommended for monolithic transparent plastic vinyl laminates are like face sheets, the same maintenance methods recommended for the monolithic transparent sheets are followed. To install a replacement transparent plastic vinyl laminate, employ the same mounting used by the aircraft manufacturer.

Exercises (811):

1. Which part of a laminated piece of plastic is considered a soft plastic material?

2. How thick is the polyvinyl-butyral portion of a laminated plastic structure?

3. When is a laminated plastic structure called unbalanced?

4. What is the maximum forming temperature that can be used with laminated plastic structures?

5. By what method should plastic vinyl laminates be mounted?

812. Given circumstances involving the fabrication, repair, and maintenance of cellulose acetate base plastics, state the most appropriate working procedure to employ.

In general, the methods used for fabrication, repair, and maintenance of cellulose acete base plastics, are similar to those used for acrylic plastics. In handling cellulose acetate base plastics, note the following variations and additions to the recommendations already given for acrylic plastics.

Bonding. Since the chemical composition of acetate base plastics differs greatly from that of acrylics, the cement used is of a different type. Generally, two types are used: solvent and dope.

Solvent type cement is generally used where transparency must be maintained in the joint. It is relatively quick-drying and is well adapted for use in making emergency repairs. However, even though the cement is quick-drying, the drying time will vary with the size of the joint and atmospheric conditions. Acetone may be used as a solvent type cement.

Dope type cement is preferred for use where the surfaces to be joined do not exactly conform. This cement softens the surfaces of a joint and, at the same time, creates a layer between the two pieces being cemented. However, it does not give a transparent joint and is slower drying than the solvent cement. It takes from 12 to 24 hours for the joint to reach full strength.

Cutting. Cold, dry cellulose acetate sheets have a tendency to chip during machining. Therefore, they should be conditioned for a period of about 24 hours at a temperature ranging from 80° to 90° Fahrenheit. If water is used as a lubricant, use it sparingly, since acetate base plastics absorb it more readily than acrylics.

When cutting, you may use an automatic metal shearing device. For thin sheets, use regular hand type tin shears. Cut only after the sheet has been conditioned, as previously described.

Forming. Acetate plastics may be formed cold if the curvature is of a simple nature and has a radius not smaller than 70 times the sheet thickness. Do not cold-form sheets below a temperature of 80° Fahrenheit. For hot-forming, the correct temperature ranges from 250° to 280° Fahrenheit. Heating time ranges from 4 to 12 minutes for sheets 3/32 to 1/4 inch thick. If heated to a temperature higher than 280° Fahrenheit, small parallel "sheeter" lines appear on the surface of the plastic sheet and impair its optical qualities. Be very careful when forming heated acetate base plastics, because forming temperatures are much more critical for these plastics than for acrylics. Acetate base plastics can be heated in hot air ducts or by blowing hot air onto the sheet while it is being formed.

Repair Factors. The expansion and contraction rates of acetate base plastics are greater than those of acrylics, so make greater allowances when mounting them. These plastics swell as they absorb water. In general, allow 1/8 inch per foot of panel length for expansion, and 3/16 inch per foot for contraction.

It is sometimes possible to clear a badly scratched surface of cellulose acetate base plastic by applying a coating of clear varnish. When polishing and buffing, follow the same procedures as employed for acrylic base plastics, except operate the buffing wheel at 1450 rpm.

Exercises (812):

1. To avoid chipping acetate plastic when cutting, what should be accomplished prior to the cutting operation?

2. Besides determining the bend radius needed based on the thickness of the plastic, what else must be considered prior to cold forming sheets of cellulose acetate?

3. How should you clear badly scratched cellulose acetate base plastic surfaces?

4. When joining surfaces of cellulose acetate base plastics that do not conform exactly, what variation in general procedures is necessary?

1-4. Repair and Replacement of Plastic Structures

Because of the optical requirements called for in today's aircraft, repairs to transparent plastic assemblies are very limited. Usually, damaged plastic assemblies such as, canopies, side panels, etc., are replaced. Minor surface restoration operations are permitted provided TO specifications and guidelines are strictly followed. Repairs involving patching are used only under conditions of extreme EMERGENCIES. Always consult the specific -3 TO before accomplishing any repair to transparent plastic assemblies.

813. Specify procedures or precautions to follow for a particular step in polishing scratches out of acrylic plastic assemblies.

Pre-Removal Procedures. The number, length, size, and depth of the scratches permitted in a given area of a plastic panel are spelled out in specific -3 TO's. Also given is the minimum acceptable thickness of the plastic panel after the scratch or scratches have been polished out. Before you start polishing out a scratch out of the plastic panel, determine how thick the panel should be after you complete the work.

If the panel thickness is less than the limit given in the applicable technical order, the panel must be replaced rather than repaired. To anticipate the thickness of the panel after the scratch is removed, use the optical micrometer before you remove the scratch. Here is what you need to know to use the optical micrometer when you measure the thickness of the panel.

a. Place a grease pencil mark on the far side of the panel and focus the micrometer on the mark. Read and record the setting on the micrometer.

b. Place a grease pencil mark on the near side of the panel and focus the micrometer on the mark. Read and record the setting on the micrometer.

c. Subtract the second reading from the first reading and multiply this difference by the constant 1.5 to get the thickness of the panel.

d. To measure the thickness of the plastic at the scratch before you rework it, use the bottom of the scratch as the focal point (instead of the grease pencil mark on the one side). Look at the illustration in figure 1-7 then follow the procedures above.

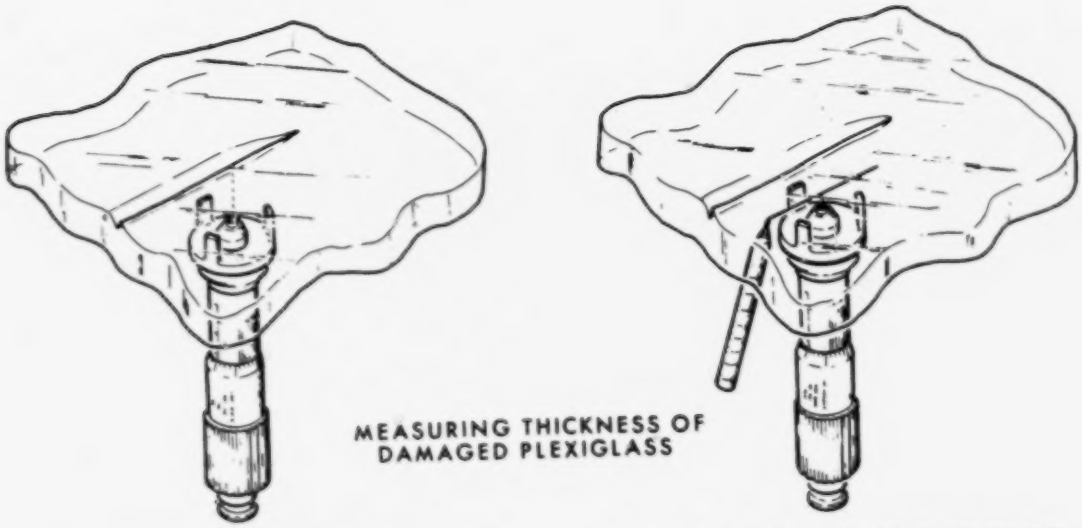
Polishing Factors. Polishing scratches is the recommended method that should be used to remove scratches from aircraft plastic assemblies. Because all other surface defects, such as, nicks, dents, chips, and cracks are not repairable, replace the plastic assembly. Materials necessary for polishing are obtainable in a Polysand Abrasive Kit, manufactured by Micro-Surface Finishing Products. Contained in this kit are various grades of abrasive sheets ranging from 600 grit to 8000 grit and step-by-step instructions.

Scratches may be polished out by either hand or power sanding. When hand sanding, do not use a grit coarser than No. 320A, nor any grit coarser than required to remove the defect. Use progressively finer grit from 400A through 8000A. Use a foam rubber or felt padded block, and always sand wet or with a 2-percent soap solution lubricant. Cover an area approximately three times greater than length of scratch, with circular movements of the abrasive sheets. (See fig. 1-8). Use no more pressure than is necessary to keep the paper cutting. Wash area down each time abrasive sheet is changed to a finer grit so that all of the preceding larger abrasive particles are removed.

When using power operated sanding equipment, follow the same general procedures as outlined for hand sanding. Use extremely light pressures and use generous quantities of water as a lubricant to prevent overheating. Carefully wash part to be sanded so that coarse grit will not be transferred to sanding wheel. Use a surface speed of 2000 feet per minute (1400 rpm for 6-inch wheel) and use light pressure. The sanding wheel can quickly overheat the acrylic plastic panel and leave marks known as "buff burns", which will necessitate replacement of panel. Use polish, Military Specification MIL-C-18767. After sanding is completed, clean and wash the affected area. NOTE: Power sanding is not recommended except on large areas.

Basic Polishing Procedures. Scratches that can be polished fall into three types; deep, minor, and hairline. Procedures outlined in the following paragraphs should be carefully followed to prevent additional damage.

a. Mark polishing limits with a soft wax pencil. Mark three rectangles or squares on the undamaged surface around the scratch or scratches to be repaired. (See fig. 1-9.) The smallest rectangle is the polish limit for the first abrasive used. The second rectangle is the polish limit for the second abrasive used. The third rectangle is the polish limit for the third and subsequent abrasives used. When each limit rectangle is



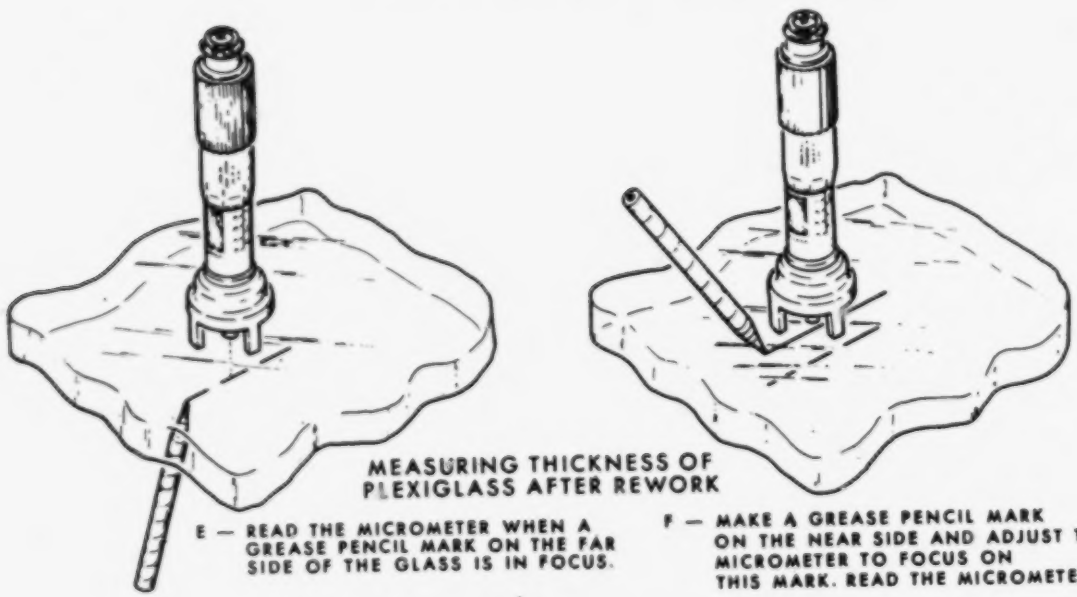
MEASURING THICKNESS OF DAMAGED PLEXIGLASS

A — FOCUS ON THE APEX OF A SCRATCH FROM THE FAR SIDE OF THE GLASS. READ THE MICROMETER.

B — MAKE GREASE PENCIL MARK ON THE NEAR SIDE AND ADJUST THE MICROMETER TO FOCUS ON THIS MARK. READ THE MICROMETER.

C — SUBTRACT READING "B" FROM READING "A".

D — MULTIPLY THIS DIFFERENCE BY THE CONSTANT 1.5 TO GET THE THICKNESS OF THE GLASS THAT WILL REMAIN AFTER SANDING OUT THE SCRATCH.



MEASURING THICKNESS OF PLEXIGLASS AFTER REWORK

E — READ THE MICROMETER WHEN A GREASE PENCIL MARK ON THE FAR SIDE OF THE GLASS IS IN FOCUS.

F — MAKE A GREASE PENCIL MARK ON THE NEAR SIDE AND ADJUST THE MICROMETER TO FOCUS ON THIS MARK. READ THE MICROMETER.

G — SUBTRACT READING "F" FROM READING "E".

H — MULTIPLY THIS DIFFERENCE BY THE CONSTANT 1.5 TO GET THE THICKNESS OF THE GLASS.

Figure 1-7. Measuring thickness of transparent plastic assemblies.

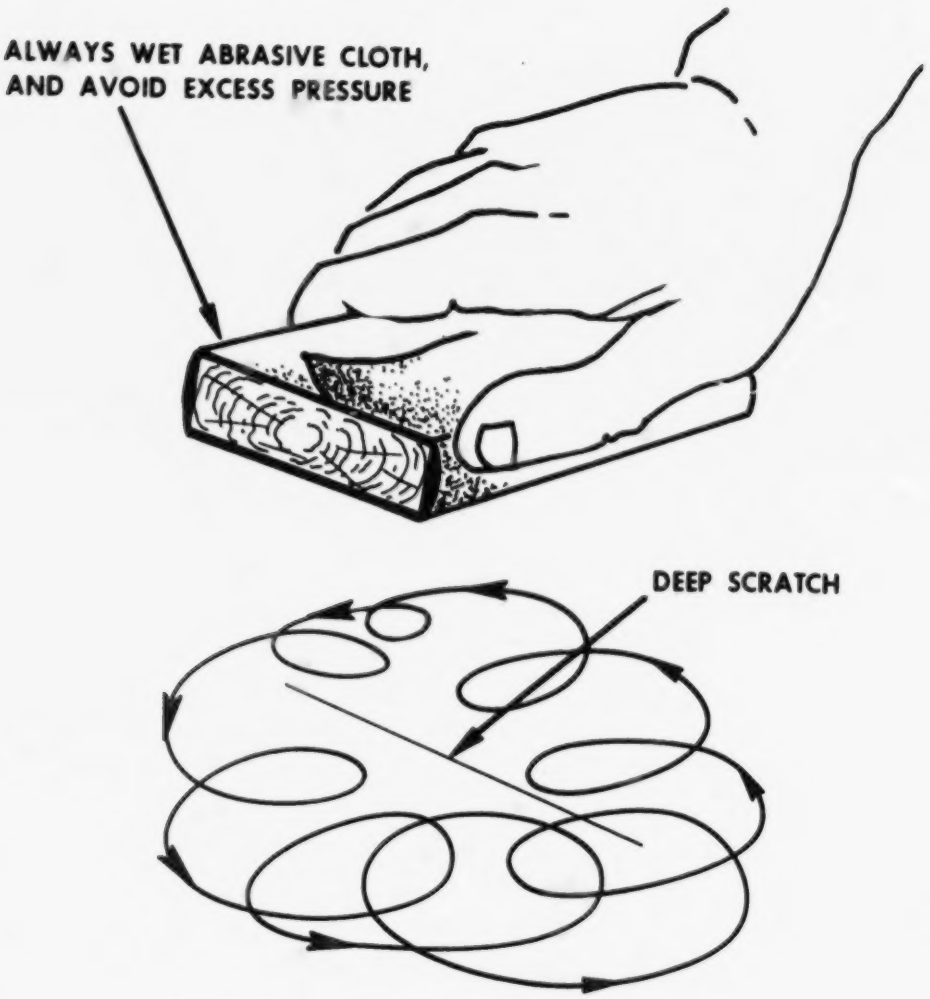

ALWAYS WET ABRASIVE CLOTH,
AND AVOID EXCESS PRESSURE
DEEP SCRATCH
SAND WITH ROTATING MOTION OVER A WIDE AREA
TO PREVENT OPTICAL DISTORTIONS
NOTE
DO NOT SAND ACRYLATE BASE PLASTIC UNLESS ABSOLUTELY
NECESSARY TO REMOVE DEEP SCRATCHES.

Figure 1-8. Proper polishing procedures—scratch removal.

oriented as shown in figure 1-9, polishing marks from the last abrasive are more easily seen and removed. All polishing marks from the last abrasive must be removed by subsequent polishing abrasive. Polishing should be accomplished in bright sunlight, to insure that all polishing marks are removed.

b. Polish each area, in succession, with the next finer grade abrasive. Use a foam rubber block and a piece of heavy paper board to stiffen abrasive material. Polishing with the first three grades of abrasive must be confined to the limited rectangles. All other grades used should overlap the largest limit area. Move the abrasive material block in a circular motion around the damaged area. Use large amounts of water and slap the abrasive material frequently with the hand during polishing. Clean the surface thoroughly between each selected grade of abrasive to remove abraded particles. Select the proper grade abrasive for damage repair. (See fig. 1-9).

CAUTION

- KEEP GRADES OF ABRASIVE MATERIAL SEPARATED, PROTECTED, AND FREE OF DIRT AND OTHER GRITTY MATERIAL. WASH ALL CLOTHS, HANDS, AND OTHER MATERIALS USED TO PREVENT FURTHER SCRATCHES OR DAMAGE.
- POLISHING WITH THE FIRST THREE GRADES OF ABRASIVE MUST BE CONFINED TO THE LIMITING RECTANGLES.
- TO PREVENT SCRATCHING PLASTIC WHILE APPLYING AND REMOVING CLEANER COMPOUND OR POLISHING PANEL SURFACE, USE FLANNEL CLOTH ONLY.

NOTE

- MATERIALS FOR POLISHING ACRYLIC PLASTIC ARE CONTAINED IN THE POLYSAND ABRASIVES KIT, PART NUMBER RS-69, MICRO-SURFACE FINISHING PRODUCTS INC, P.O. BOX 456, WILTON JUNCTION, IOWA, 52778.
- ANY TIME A COMPONENT OF THE COCKPIT ENCLOSURE GROUP IS REMOVED FOR REPAIR, STORAGE, OR TRANSPORT, THE ACRYLIC PLASTIC PANEL MUST BE PROTECTED FROM FURTHER DAMAGE BY APPLICATION OF A PRESSURE-SENSITIVE ADHESIVE PROTECTIVE PAPER SIMILAR TO PRO-TEX, PART NUMBER 8135P20V, MASK-OFF CO, P.O. BOX 585, 345 NORTH MAPLE AVE, MONROVIA, CA, 91016.

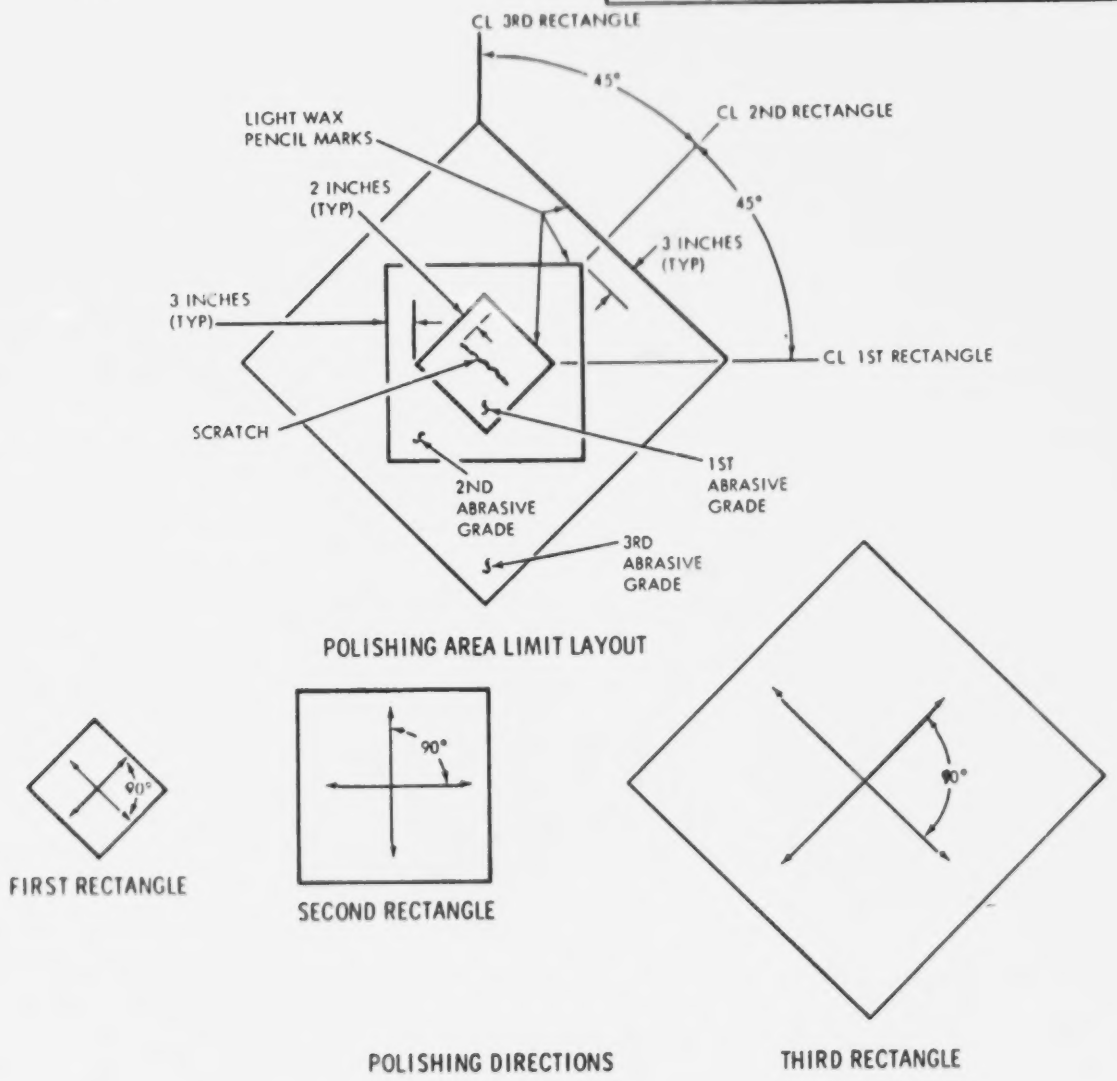


Figure 1-9. Polishing data—scratch removal.

The type of scratch being polished out determines the numbers of abrasive grades that will be needed. Keep all grades of abrasive material separated, protected, and free of dirt or other gritty material. Wash all cloths, hands, and other materials used to prevent further scratches or damage.

Exercises (813):

1. How do you determine if scratches are permitted in a given area of a plastic panel?

2. How do you determine if a scratch may be polished out?

3. What is the coarsest grit sand paper that you may use when hand polishing plastic parts?

4. What speed and pressure should you use when power sanding with a 6-inch wheel?

5. How are limits for each of the polishing steps indicated?

814. State the reason for specific steps in removing and replacing transparent plastic assemblies.

There are a number of methods by which transparent panels can be installed in aircraft. The method chosen by the manufacturer depends on the position of the panel on the aircraft and design stresses. When installing a replacement panel, follow the method of mounting given by the manufacturer.

General Factors. Plastic panels are reasonably flexible; but if they are forced into a frame, high or unequal stresses may set up in certain areas of the panel. When acrylic plastics are subjected to excessive stresses, they are apt to craze. This lowers the transparency and strength of the panel. It is important, therefore, that plastics be mounted so that internal stresses are avoided or kept to a minimum. If the replacement does not fit loosely into the mounting, obtain or form a new replacement or heat and reform the panel. However, reformed panels are not placed in areas where clear vision is critically important; replace with a newly formed panel. It is not advisable to heat and reform areas, as local heating methods are likely to be only superficial and not thorough enough to reduce stress concentrations. Fitting and handling is done with masking material in place. To scribe plastic, remove the masking material. On the edges where transparent materials will be covered by attachments, remove the masking material. Also, since transparent plastics are brittle at low temperatures, installation should be done at normal temperatures, if possible.

Removal Factors. During the removal of plastic assemblies, there may be several different lengths and material composition of screws to be removed. You will save yourself a lot of problems later, if you separate the different types of screws as they are removed. An easy way to do this is to draw a diagram of the assembly on cardboard, denoting the location of each screw hole. As each screw is removed, install it in its respective location on the cardboard. During installation of the panel, reinstall each screw in the same hole from which it was removed.

When a complete canopy frame assembly is removed from the aircraft for canopy replacement, the frame assembly should be mounted in a holding fixture. This prevents the frame assembly from shifting when the canopy is removed. Alignment measurements should be taken prior to removing the canopy from the frame. After the new canopy is installed, repeat the same alignment measurements, Properly matching measurements indicate that the frame hasn't shifted during canopy installation. NOTE: All plate nuts should be checked for proper operation, while the canopy is removed.

Pre-Installation Factors. Before installing plastic into the retaining frames, the surface are cleaned with aliphatic naphtha, TT-N-95. Apply naphtha with a clean cheesecloth or a small paintbrush and wipe dry before evaporation can occur. Repeat cleaning until surface is free of residual film. Wipe surface dry with a clean cheesecloth or cloth. The surface is ready for you to apply tapes, adhesives, gaskets, sealants and seals. General procedures for removing sealants is to scrape existing material from the area with a sharp knifelike tool made of phenolic or hardwood material. When sealants are difficult to remove, apply a stripper compound, Turco 2822. Scrape off loosened sealant at short intervals and reapply stripping compound until all old sealant is removed. Remove stripping compound, using an approved solvent such as methyl ethyl ketone (MEK). Before sealing, reclean surface with aliphatic naptha and let dry. The surface must be dry before sealing.

Installation factors. Acrylic plastics expand and contract approximately three times as much as the metal channel in which they are mounted; suitable allowances must be made and specific rules must be followed during the mounting procedure. Allowances for dimensional changes with temperatures must be made. Use the values shown in figure 1-10 as minimum clearances between frames and the plastics. If possible, avoid bolting or riveting through the plastic sheet. Channel and clamp mountings distribute stress of

ALLOWANCES FOR DIFFERENTIAL EXPANSION AND CONTRACTION*

DIMENSION OF PANEL IN INCHES	DIMENSIONAL ALLOWANCE IN INCHES ** ***	
	REQUIRED FOR EXPANSION FROM 25°C(77°F) TO 70°C(158°F)	REQUIRED FOR CONTRACTION FROM 25°C(77°F) TO -55°C(-67°F)
12	0.031	0.050
24	0.062	0.100
36	0.093	0.150
48	0.124	0.200
60	0.155	0.250
72	0.186	0.300

*WHERE THE CONFIGURATION OF A CURVED PART IS SUCH AS TO TAKE UP DIMENSIONAL CHANGES BY CHANGE OF CONTOUR, THE ALLOWANCES GIVEN MAY BE REDUCED IF IT WILL NOT RESULT IN LOCALIZED STRESS.

**FOR DIMENSIONS OTHER THAN THOSE GIVEN USE PROPORTIONAL CLEARANCE.

53-1904

***INSTALLATIONS PERMITTING LINEAR CHANGE AT BOTH ENDS REQUIRE HALF THE LISTED CLEARANCES.

Figure 1-10. Plastic expansion and contractor allowances.

expansion evenly throughout the sheets. Therefore, such mountings should be used if possible. In figure 1-11 are drawings of some mountings. Do not use bolt and rivet installations that go through the transparent plastic on pressurized aircraft. Where you encounter difficulty in rivet installation, substitute bolts when installing replacement panels, provided they meet the manufacturer's original strength requirements and the bolts do not interfere with adjoining equipment. In bolt installations, use collar spaces, shoulders, or stop nuts to prevent excessive tightening of the bolt. Whenever such devices are used by the aircraft manufacturer, retain them in replacement installations.

Screws torquing procedures should be in accordance with the applicable -3 TO instructions. Do not subject plastics assemblies to unnatural stresses during installation. Each screw must be torqued as specified to enable it to carry its portion of the load. If a plastic assembly is installed in a binding or twisting position and the screws are not torqued correctly, the plastic

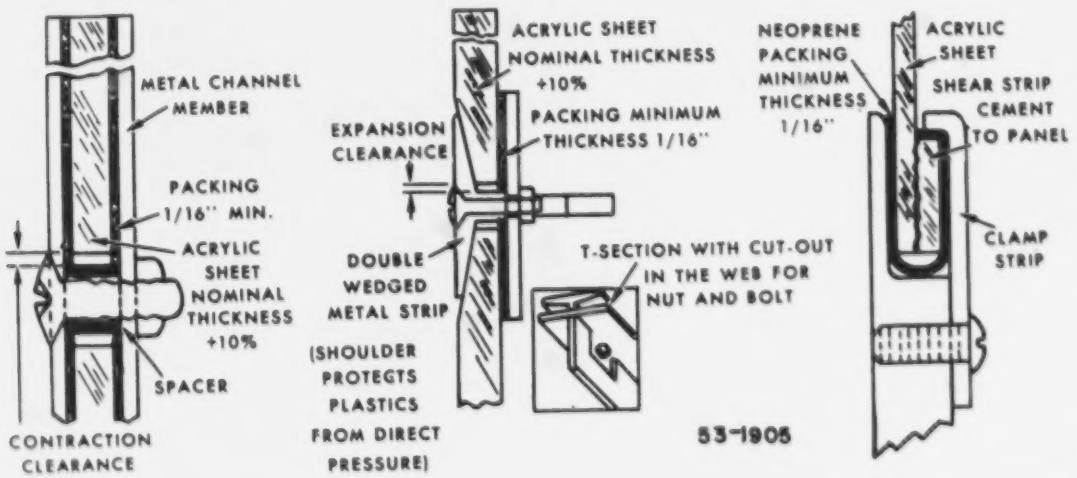


Figure 1-11. Methods of mounting plastic panels.

assembly may fail. One method of reducing unnatural stresses and at the same time, reduce hole misalignment, is to install screws diagonally back and forth across a plastic assembly in a criss-cross position.

Exercises (814):

1. When installing acrylic plastics, why should you be careful *not* to subject the assembly to stress by forcing it into the frame?

2. Why should a cardboard diagram of an assembly be made prior to removing a plastic panel?

3. Why should alignment measurement be taken before and after replacing a canopy from a frame assembly?

4. For what reason would you use Turco 2822 stripper compound when cleaning plastic assembly retaining frames?

5. Why is it important that fastener holes drilled in acrylic plastics be within TO specifications?

6. Why should you tighten screws in a criss-cross pattern when installing plastic structures?

Fiberglass Structures

PLASTIC CARS, the transportation of tomorrow? Except for a few components, such as engines and transmission gears, the cars of the future could well be made entirely of plastics. The use of plastic material in the construction of today's cars is not limited only to interior plastics, such as panels, upholstery, fasteners, etc., but plastics reinforced with fiberglass are being used to make chassis parts. Adhesive bonding is stronger than metal welds; thus, those pesky squeaks and rattles from loose bolts and screws are being eliminated. Fiberglass already is used in the manufacture of many aircraft components and parts such as radomes, antenna covers, junction boxes, wingtips, tanks, and heater ducts. It is unequaled in the strength-to-weight ratio and has the ability to allow radio and radar waves to pass through. Fiberglass is easy to manufacture into different shapes, is immune to mildew, and has good weather-resistant characteristics.

In this chapter you study the construction features, evaluation of damage, repair materials, tools, and equipment used in the repair of fiberglass components. Information on maintenance procedures, inspections, and safety precautions are also discussed. Typical repair techniques are explained to help you understand the maintenance and repair of fiberglass components and parts. The information given will greatly help you to acquire the skill needed in repairing fiberglass assemblies.

2-1. Fiberglass Assemblies

Fiberglass is manufactured from specially processed glass balls by a process in which the glass is turned into fibers (see fig. 2-1), the end products being cloth, molded mats, or yarn. Fiberglass is durable, flexible, fireproof, and very stable. Glass fibers have a high tensile strength; and because of the moisture resistance quality, they will not shrink, stretch, rot, or decay. Fiberglass resists most acids, alkalis, oils, solvents, sea water, and corrosive atmospheres.

Fiberglass assemblies are used on aircraft as radomes, junction boxes, wing tips, and many other applications. Parts made of fiberglass are light, strong, and very rigid, and in the case of radomes are excellent for the transmission of electronic signals.

815. Given characteristic features of fiberglass assemblies, specify the specific types.

Mat Molded Fiberglass. Glass fibers act as a reinforcement for epoxy or polyester resins in the construction of fiberglass assemblies. The assemblies are fabricated by a process wherein the chopped fibers are molded around a form, bonded together by use of a resin, and cured under heat and pressure. *Fiberglass mat* is made of short chopped fibers of different lengths and molded in a random pattern, as shown in figure 2-2. *Mat molded* fiberglass is made by using fiberglass mat (pattern is cut from flat mat), adding the desired resin, and placing the material between a male and female die. It is then cured under heat and pressure, and results in a configuration as shown in figure 2-3. Nonstructural parts, such as junction boxes, relay shields, and ducts, are manufactured from mat molded fiberglass.

Laminated Fiberglass. This type of fiberglass construction consists of two or more layers of fiberglass cloth saturated with a catalyzed resin and bonded together with the aid of heat and pressure. The lower illustration in figure 2-4, shows this type of construction. Fiberglass laminates, sometimes called *solid wall type* or *solid laminate construction,* are widely used in fabricating aircraft antenna housings for communication, navigation and radar equipment.

The properties of fiberglass laminates are affected by such things as conditions of exposure (temperature, moisture, and weather), thickness of laminates, and variables of fabrication. In many applications, laminates are exposed to moisture in the form of either high humidity or free water. The amounts of moisture absorbed are generally quite small; but under long exposure the strength properties are decreased. The amount of decrease depends on the type of finish applied to the fabric, exposure site and type of resin, as well as the reinforcing agent used. Laminates made with polyester, epoxy, phenolic, and silicone resins have withstood up to 3 years weathering without severe reduction in strength properties. Laminates should be kept painted to reduce erosion of the resin on the exposed face. Moisture in laminates will reduce the electrical properties. The strength properties of glass fiber base laminates at elevated temperatures are dependent on the laminating resin used. The polyester resins conforming to Military Specification MIL-R-7575 vary in heat resistance, but most of the resins produce laminates that retain a large share of

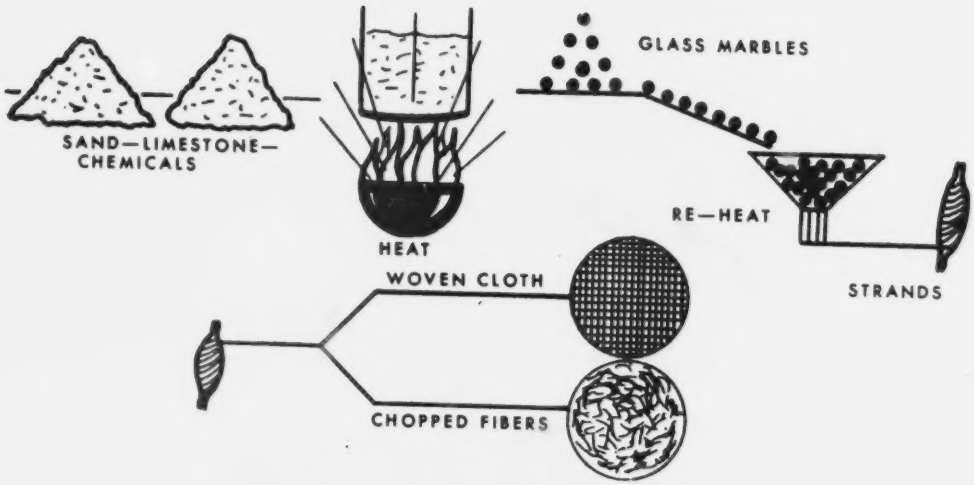


Figure 2-1. Manufacturing process of fiberglass.

their strength at temperature from around 76° F., to as high as 200° Fahrenheit. A few of them retain much of their room temperature strength at even 300° Fahrenheit. Epoxy resins conforming to Specification MIL-R-9300 also vary in heat resistance. Heat-resistant resins are being designed for high-temperature use.

Fiberglass Honeycomb. Fiberglass radomes and parts consist of a fiberglass honeycomb core to which face plies of laminated glass cloth are bonded. The upper portion of figures 2-4 illustrates this type of fiberglass assembly. This type of structure has proven very satisfactory because of its excellent dielectric qualities, strength, and resistance to weather erosion, etc. The core is used to separate the outer layers, or facings, to obtain a panel of high bending stiffness and to support the facings. The core keeps the facings elastically stable when highly stressed. This construction makes strong rigid parts with a minimum amount of weight.

By varying the sheet material, sheet thickness, cell size, and cell shape, cores of a wide range in density and properties can be produced. Most cores available are of hexagonal, sine wave, or square cells, as shown in figure 2-5. Requirements of greater importance than strength properties normally dictate the choice of core materials for radio and radar enclosures. Properties such as the dielectric constant, the loss tangent, and an exceedingly low rate of moisture absorption are of greatest importance. Strength is of great importance for large enclosures.

The core material in fiberglass enclosures is of the type and thickness as specified in the applicable design drawing. One of the most common core materials in fiberglass enclosures is made of glass cloth impregnated with a polyester or a combination of nylon and phenolic resin. Honeycomb core cell sizes, (determined by the diameter of a circle inscribed in a cell) range from 1/16- to 3/8-inch diameter (usually in multiples of 1/16-inch). Honeycomb material is normally fabricated in blocks that can be cut on a band saw to the desired size or can be procured precut to the proper thickness.

The honeycomb cores fabricated from nonmetallic materials have very good thermal insulation characteristics. In considering thermal effects, keep in mind that fiberglass honeycomb acts as a reflective heat

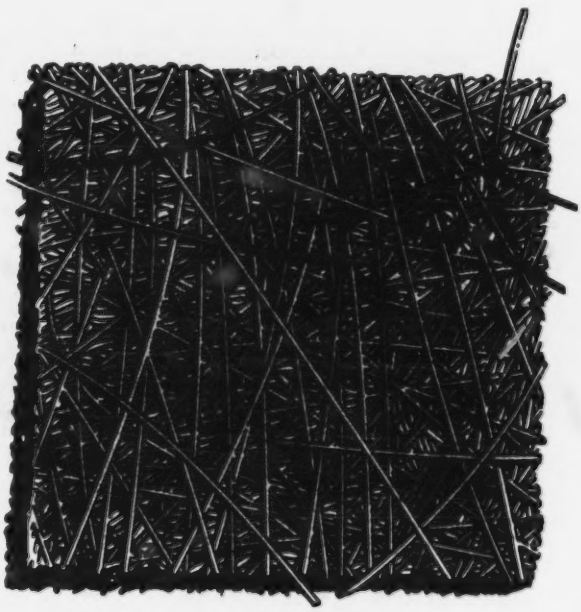


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Figure 2-2. Fiberglass mat.

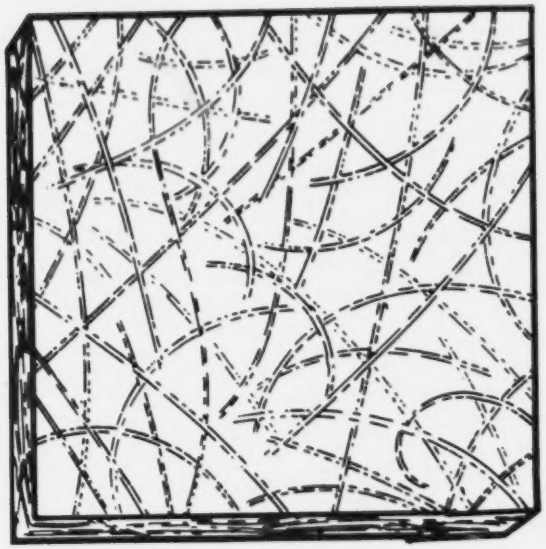

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Figure 2-3. Mat molded fiberglass.

insulator. The strength of the honeycomb depends on the cells maintaining their shape and position to support the skins that carry the major applied loads.

Exercises (815):
At the end of each statement, write in the types of fiberglass assembly described in the statement.

1. Chopped fibers are molded around a form, bonded together by use of a resin, and cured under heat and pressure.

2. A core is used to obtain a panel of high bending stiffness and to support the facings.

3. Consists of two or more layers of fiberglass cloth bonded together with the aid of heat and pressure.

4. Properties such as the dielectric constant and loss of tangent are factors considered when fabricating this type of fiberglass assembly.

5. Mostly used for nonstructural parts.

816. Given a list of characterizing statements about fiberglass radomes, differentiate between the types.

The protective dome or fiberglass enclosures on aircraft are coverings for radar equipment and radar antennas. They are called radomes. Fiberglass radomes must be able to withstand the effects of hail, icing, rain, wind, temperature and static changes, supersonic speeds, and stratospheric altitudes.

Besides the honeycomb core type of radome, other fiberglass radomes are in use today. Each has a specific type of construction that sets it apart from each other. The following are descriptions of the fluted, form, and filament wound types of radomes.

Fluted Core Type Radome. Some aircraft require the use of a hot air deicing type radome. This type of sandwich is constructed similarly to other plastic sandwich radomes with one exception: it has a series of specially designed glass cloth laminated flutes on a foam core casing. The flutes are placed in the longitudinal direction and interconnected to a hot air inlet and outlet. This allows hot air to circulate through the ducts (flutes). The entire radome can then be subjected to a certain degree of heat.

Some radomes are of three-layer and five-layer construction. The upper portion of the radome consists of three layers: (1) an outer facing, (2) a structural core, and (3) an inner layer of fiberglass plies. The lower portion of the radome consists of five layers: (1) an outer facing, (2) anti-icing ducts, (3) middle membrane (fiberglass plies), (4) structural core (honeycomb or foam core), and (5) the inner facing.

Form Core Type Radome. Some of the small irregularly shaped fire control or "gunlaying" radomes incorporate a "foamed-in-place" core material of one of the formulations based on the combinations of alkyd resins and metaloluene di-isocyanate. Foam is used as a lightweight reinforcing material for structural parts. It is used to dampen and eliminate vibration. To overcome fabrication problems, foam fills even some of the intricate cavities such as some ailerons, rudders, elevators, and wingtips.

Radomes used on aircraft are manufactured to very close tolerances on overall thickness, thickness of facings, and thickness of the core material. The materials used must allow the electrical magnetic beam to pass through without being deflected, distorted, or impeded. To achieve this accuracy, the cores are developed by pouring resin into a mold lined with thin layers of fiberglass. The resin immediately foams up to fill the entire enclosure. The close tolerances required for its effectiveness make little allowance for shrinkage or expansion. After the foam solidifies and cures, it is securely bonded to the fiberglass laminates forming a lightweight rugged radome.

Filament-Wound Type Radomes. Filament-wound type radomes are usually found on fighter-type aircraft. Filament-wound radomes are fabricated by winding fiberglass rovings in alternate layers, perpendicular to each other, over a mold. The layers of

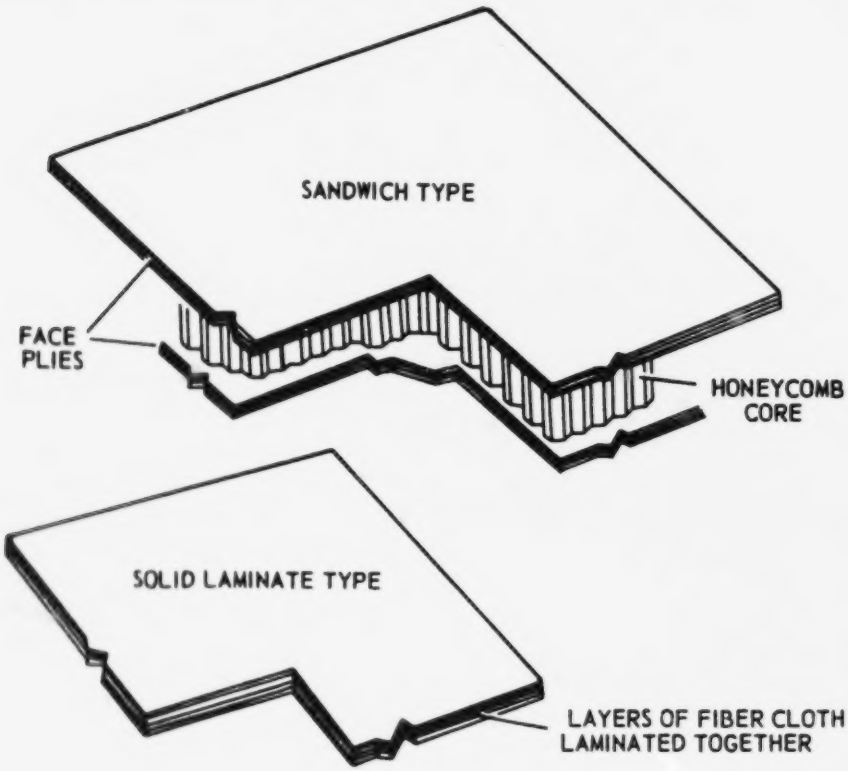

Figure 2-4. Types of fiberglass structures.

the roving that run the circumference of the radome are called *ceres*, and the filaments wound around the radome lengthwise are called *longues*. Each layer is saturated with catalyzed resin and then the cone is cured to provide a strong, flexible radome. This construction fracture is similar for all types of filament-wound radomes. NOTE: For repairs and damage classification guidelines consult the specific -3 TO. General information is given in TO 1-1A-24. *Maintenance Repair and Electrical Requirements for Fiberglass Airborne Radomes.*

Exercises (816):
Match the types of fiberglass radomes listed in column 2 to a specific description, given in column 1, by placing the number of the specific radome, in the space provided in front of the statements listed in column 1.

Column 1

_____ 1. Radome has anti-icing ducts.
_____ 2. Primary used for fire control radomes.
_____ 3. Construction features will vary from three-layers or five-layers of laminates.
_____ 4. Usually used for radomes on fighter-type aircraft.
_____ 5. The entire radome can be subjected to a certain degree of heat.
_____ 6. Core material is used to dampen and eliminate vibration.
_____ 7. Constructed by winding fiberglass rovings in alternate layers.
_____ 8. Terms such as ceres and longues are used to describe this type of radome construction features.
_____ 9. Core material is a formulation based on the combinations of alkyd resins and metatoluene di-isocyanate.
_____ 10. Different types of core material may be used.

Column 2

(1) Fluted Radome
(2) Foam Radome
(3) Filament-Wound Radome

817. Given a description of a damaged fiberglass assembly, classify the type of damage.

Mat Molded Damage Evaluation. To determine the extent of damage, the affected area should be wiped

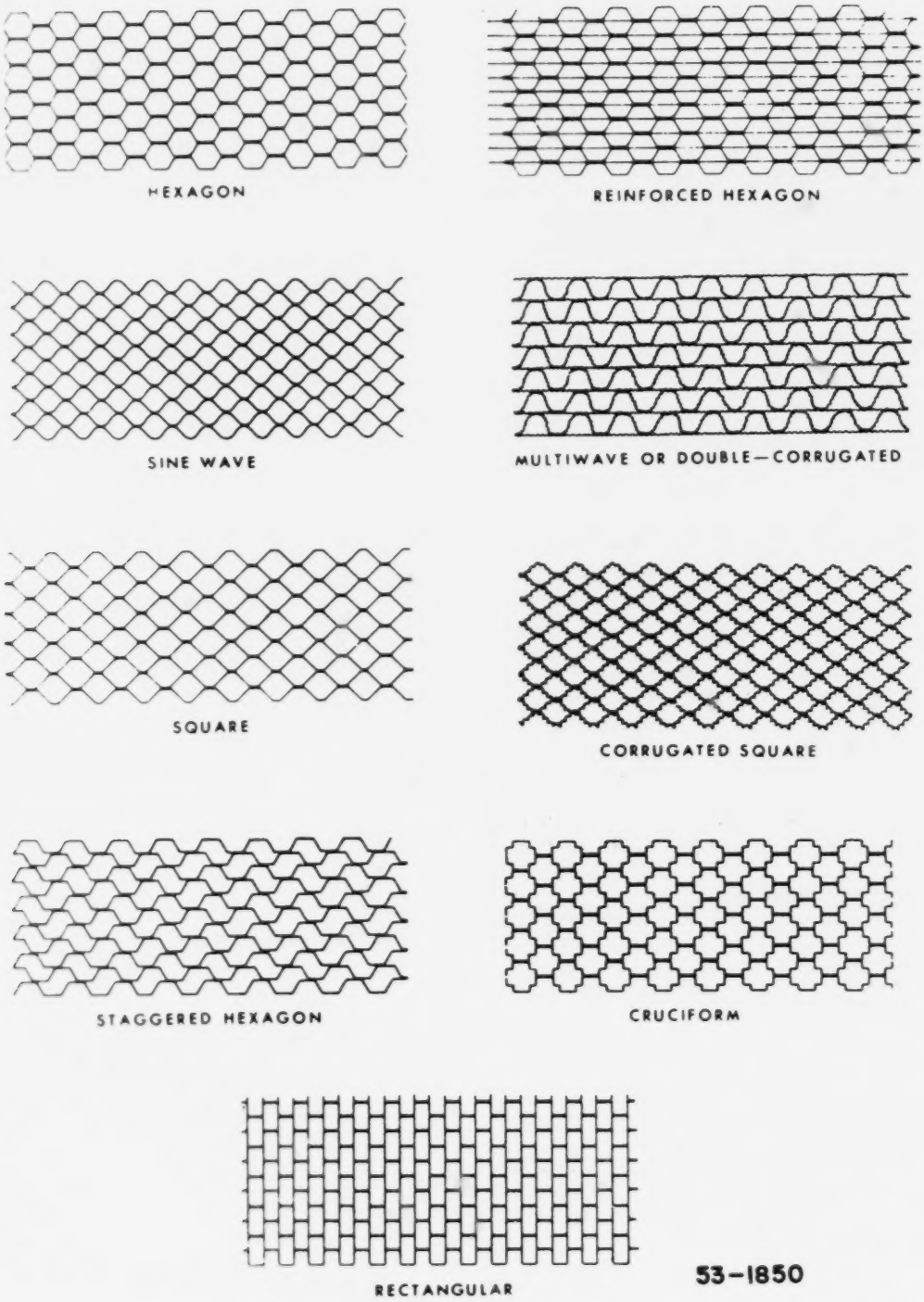

Figure 2-5. Honeycomb core cell configuration.

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with a clean cloth saturated with methyl ethyl ketone (MEK). If there is paint on the surface, remove it by lightly sanding the area with number 280 grit sandpaper. Clean the area again, being sure to remove all grit. Careless handling and vibration are the two causes of damage to parts. Damage to mat molded parts usually consists of a hole or a crack in the assembly. The length and size of the hole indicate whether it is a minor or major repair. In the classification of repairs, longer cracks and larger holes are considered as major repairs. The applicable section in the -3 technical order for the specific aircraft will give you the information to help you in classifying the damage.

Laminated Damage Evaluation. Visually inspect the aircraft component or part for scratches, surface cuts, erosion, cracks, dents, holes, delaminations, and erosion of protective coating. A strong light placed behind the defective area is helpful in detecting certain types of damage. When you are inspecting, carefully examine the interior surfaces for small delaminations under 1 inch in diameter. The spot delaminations or perforations (pinholes in inner and outer skins) are generally caused by electrical static discharges and can be identified by an area with a dark center or an evidence of burned resin.

To help you classify the damage, many manufacturers include in the technical order a damage evaluation chart by which you can determine the types of damage and where to find the repair procedures. It will give you the type allowable, reparable damage, and the paragraph number for repair procedures. Some manufacturers also classify the damage as either minor and major repair and give you procedures for each type. A minor repair can be considered a repair that can be made in a very short period of time. You can consider a minor repair to be a crack of less than 1/2-inch. A major repair is a crack of more than 1/2-inch in length.

Fiberglass Honeycomb Damage Evaluation. Inspection procedures for honeycomb fiberglass radomes and parts are the same as laminated fiberglass parts. Surface damage to the face plies and core can be detected by visual inspection. When inspecting the core material, place the radome between yourself and a strong source of light. The translucency of the part will permit you to observe any defects in the core material. An ideal core bond will be observed as a substantial fillet of resin at each core skin interface, but the absence of a fillet is not conclusive evidence of an inadequate bond. However, its absence will require you to further check the area. When you notice the resin fillet is missing, check the area, using the metallic ring test.

To help you inspect a damage, the following list defines terms that are most used. The illustrations in figure 2-6 also define damages.

a. Perforations - holes punched through all plies of fiberglass facing.

b. Delamination - separation of two or more fiberglass plies caused by improper bonding, part being dropped, or struck by heavy object.

c. Separation of fiberglass facing from honeycomb core - caused by improper bonding, part being dropped, part being struck by heavy object, or water freezing in honeycomb core.

d. Core damage - damage to honeycomb core caused by an object piercing the face plies and core or crushing of panel.

e. Small spot or electrical discharge - small hole through inner and outer facing and honeycomb core caused by discharge of static electricity. This type is found mainly in radomes.

Many manufacturers have limitations on repairs that can be made in the field. The specific technical order contains limitations for radomes. A radome requiring an electrical test after a repair is sent to a depot for repairs.

Damage to fiberglass honeycomb radomes is categorized according to the severity, possible effect upon the structure of the aircraft, and upon electrical efficiency. Each manufacturer has a different method of grouping and classing the repairs. For this course, the damages have been classified into three classes, depending on the type of repair required to fix the damage. The following is a description of each class:

- A Class I repair is a scar, scratch, surface abrasion, or minor rain erosion not penetrating through the first facing. The repair for these damages is the same as given for laminate fiberglass.
- Class II repair consists of a damage extending through two plies of the plastic facing or completely through one facing of the radome and possibly into the core.
- Class III repair is made to fiberglass radomes when both facings and core have been damaged.

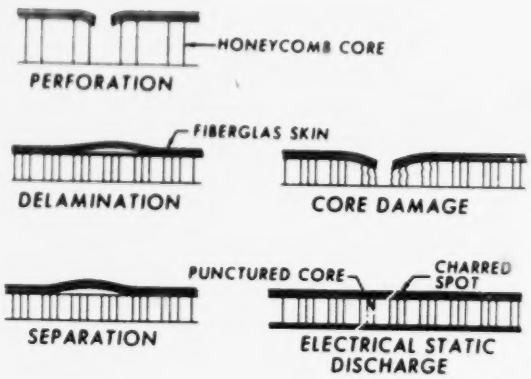

Figure 2-6. Definition of damage terms.

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Exercises (817):
After each statement, give the type of damage classification required.

1. Radome which has both facings and core damaged.

2. Laminated structure which has a 1-inch crack through all plies.

3. Mat-mold structure which has a 1/8 of an inch crack leading out from a fastener hole.

4. Radome which has a scar on the outer facing.

5. Radome which has damage to two plies of the top or bottom facings.

6. Radome which has damage through the top plies and into the core material.

7. Damage to a laminated structure which can be repaired in a very short period of time.

2-2. Maintenance of Mat-Molded Fiberglass

When making repairs, your main objective is to equal as nearly as possible the strength and electrical properties of the original part. You also want to keep the weight at a minimum. This you can accomplish by using approved materials and working techniques. Maintaining smoothness of the outside surfaces and uniformity in thickness of facings is very important. When you make deviations from the technical order, they can hinder the function of proper radio and radar reception and transmission. Repairs of punctured facings and delaminations will necessitate removal of damaged material and its replacement with approved materials, the same thickness as the original being carefully maintained.

After leaving a resident course you will train from 3 level to 5 level. Upon entering your new duty station you may have difficulty in the techniques and materials involved in repairing fiberglass unless you have had actual experience in making repairs. Watch an experienced man and have him help you to make a repair on an unusable part. All repairs made to aircraft parts or components are inspected by qualified personnel. They inspect for uniform thickness, void freeness, smoothness, and quality bonding of the fiberglass cloth and resin material. When you are slated to make a repair on an aircraft component or part, be sure to use the technical order for the specific aircraft you are to repair.

818. From a list of statements concerning the basic materials, tools, and equipment used to repair mat molded fiberglass structures, identify the true statements and explain why the others are not correct.

The following paragraphs will give you information on the uses, characteristics, and functions of materials, tools, and equipment you will use in the repair of mat molded assemblies.

Polyvinyl Alcohol Film. Polyvinyl alcohol (PVA) film is a plastic material used as a parting agent between the saturated fiberglass mat and the metal used to hold the material in place during the curing process. It is water soluble and can easily be removed from the repair when necessary. You will note that the film has has a tendency to curl on the edges and looks cloudy. When heated it will stretch to contours and all wrinkles can be smoothed out.

Cellophane and polyvinyl chloride sheets are plastic parting agents used in places similar to those in which PVA film is used. Although they do not stretch, but will wrinkle and cause imperfections on the surfaces. They tend to harden when heat is applied. The material is transparent and very clear. The parting sheets must be at least 0.003 inch thick for repair use. For the most part, you will use this material where you have a single curvature and flat surfaces.

Fiberglass Mat. Fiberglass mats are sheets of molded mats made from fiberglass threads and are used in the repair of mat molded assemblies. They are used to build up the section beveled out of the assembly during repair procedures. Fiberglass mat, bender type 216, is the preferred material. Glass fabric cloth No. 128 or No. 182 are satisfactory alternates.

Bonding Agent. The bonding agent used for mat molded fiberglass repairs normally consists of three parts; a resin, a catalyst, and a promoter.

Resin. Usually, polyester type resin is used to bond the molded mat to the assemblies when making repairs. It is manufactured from one of the family of hydrocarbon chemicals and comes in liquid form. Many companies manufacture it under their own trade names. All resins must meet Specification MIL-7575. They are not used in their original state for the repair but must have other chemical materials added so that they will adhere and harden (cure). When a certain chemical or agent known as a catalyst is added, the resin changes from a liquid to solid. When this change takes place, it is known as the process of polymerization. The term polymerization can also mean to set, harden, or cure. Once the resin

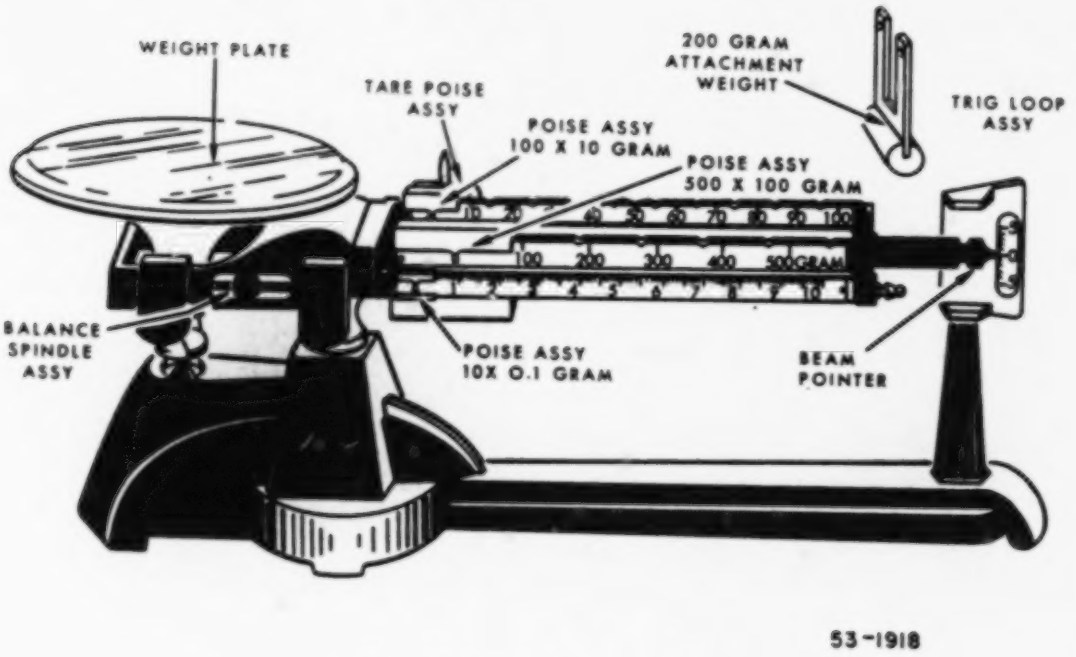

Figure 2-7. Triple beam balance scale.

has hardened, it cannot be changed back to a liquid state again.

Catalyst. Since resin is liquid and has no strength, it is obvious that something must be added to cause the resin to harden. A catalyst is the chemical agent that causes the chemical action of the resin hardening. Methyl ethyl ketone peroxide (MEKP) and benzoyl peroxide (BZP) are two common catalysts used with polyester resin. Always add the catalyst last because the chemical reaction starts immediately. CAUTION: DDM, benzoyl peroxide, and acetone are highly inflammable. Observe proper fire precautions when you handle such materials.

Promoter (drying agent). Since resin is an air-inhibitor, which means that although it will polymerize or cure, it returns a tacky surface that is not ideal for proper finishes, a drying agent is needed. A drying agent such as cobalt octoate or cobalt naphthanate is added to the resin, regardless of whether a room-temperature or a heat-cure catalyst is used. (CAUTION: Never mix concentrates of cobolt and DDM together. AN EXPLOSION WILL RESULT. All chemicals should be mixed at room temperatures.)

Triple Beam Balance Scale. Resins, promoters and catalysts are all usually measured by gram weight to insure that the correct proportion of each ingredient is used for the mixture. It is very important that the right amounts of each are used, as the addition of too much of any one would cause the mixture to cure improperly. A scale such as the one illustrated in figure 2-7 is the most accurate measuring method that can be used. Amounts can be correctly measured by placing a paper cup on the scale, weighing it, and then pouring the desired amount of each ingredient needed into the cup. Combine the mixture by stirring with a wooden paddle. A paddle can be made of any material that will not cause a chemical reaction with the resin mixture.

Miscellaneous Items. Any piece of metal that will give satisfactory holding strength can be used in repair procedures. Its primary purpose is to hold the repair materials under slight pressure and in the original contour when clamped to the assembly being repaired. Use ordinary C-clamps to hold the metal plates and repair in place. Tighten the clamps to a snug fit, but never overtighten.

Any air circulating furnace will do a satisfactory job in curing repairs. The furnace should be capable of maintaining a temperature of 220° to 250° Fahrenheit. (Other curing equipment that can be used for the repair will be discussed in later paragraphs.) Tools needed for repairing are a compass, straightedge, knife, scissors, spatula, air drill and bits, rotary file, and disc sander.

Exercises (818):

1. Identify true and false statements by placing the letter T or F in the space provided.

____ a. Polyvinyl alcohol (PVA) film is a binder used to bond fiberglass fibers together.

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___ b. Most resins used for mat molded repairs must meet specification MIL-7575.

___ c. A promoter is added to resins to change the resins from a liquid to a solid.

___ d. A catalyst is needed for the process of polymerization to occur.

___ e. Methyl ethyl ketone peroxide (MEKP) and benzoyl peroxide (BZP) are two common catalysts.

___ f. Cobalt octoate or cobalt naphthanate are drying agents.

___ g. Cobalt and DDM are mixed together before adding the resin.

___ h. Mixing of chemicals should be accomplished at room temperatures.

___ i. Chemicals are measured in gram weights.

___ j. Air circulating furnace should be capable of maintaining a temperature of 120° F. to 150° F.

2. Based on your answers to exercise 1, state the correct answers for all the false statements.

819. Explain specific procedures used to repair mat molded fiberglass parts.

The following procedures are typical and can be used to repair a mat molded assembly. When you are to work on an aircraft part, select the correction section for the repair in the technical order for the specific aircraft and follow those procedures.

Preparation of Damaged Area. Once you have classified the damage as either major or minor (see fig. 2-8), the damage surface must be prepared. Any paint or protective coating from around the damaged area must be removed prior to starting a repair.

For a crack repair, prepare the surface as follows:

a. Stop drill the ends of the crack using a 3/16 of an inch diameter twist drill.

b. Remove one-third of the material from both sides (front and back) of the crack, as shown in figure 2-8. (Use 3/4 of an inch as a corner radii.)

c. Bevel the area 15° to 45°.

d. Sand 1/2 of an inch beyond the beveled area.

NOTE: When holes are being repaired, use the same techniques of surface preparation.

Resin Mix Preparation. Whether the repair is to be air-cured or heat-cured will determine the proper resin mixture. A resin mixture prepared for air-curing, cures at room temperatures between 70° F. to 125° F. This resin mixture has a bench-life of 30 to 60 minutes at 77° F. and takes approximately four hours to completely cure. A resin mixture prepared for heat-curing, cures at temperatures between 220° F. to 250° F. They cure in approximately 30 minutes and have a bench life of seven days at 70° F.

Resin mixing should be done with the materials at room temperature to insure homogeneity. Stored resins and catalysts must be brought to room temperature in closed containers to avoid moisture absorption before mixing. Resins and catalysts should be stored at temperatures at 75° F. or less. Refrigerated storage greatly prolongs the otherwise limited room temperature storage life. Any resin that appears at room temperature to be gelled or substantially changed from its original viscosity should not be used. Use acetone to clean containers and equipment used to mix resins. (WARNING: To prevent skin irritations when handling resins, you should wash with soap and water at frequent intervals. Cleaning solvent may cause infections and irritations if used to remove resins from the skin.)

Lay-up Procedures. Once the surface is prepared and the proper resin mixture prepared, you are ready to apply the repair material to the damaged part. General techniques to follow are:

a. Cut two pieces of PVA film large enough to cover the repair area.

b. Cut two pieces of aluminum metal large enough to cover the repair area. These will hold the repair in place during the curing time.

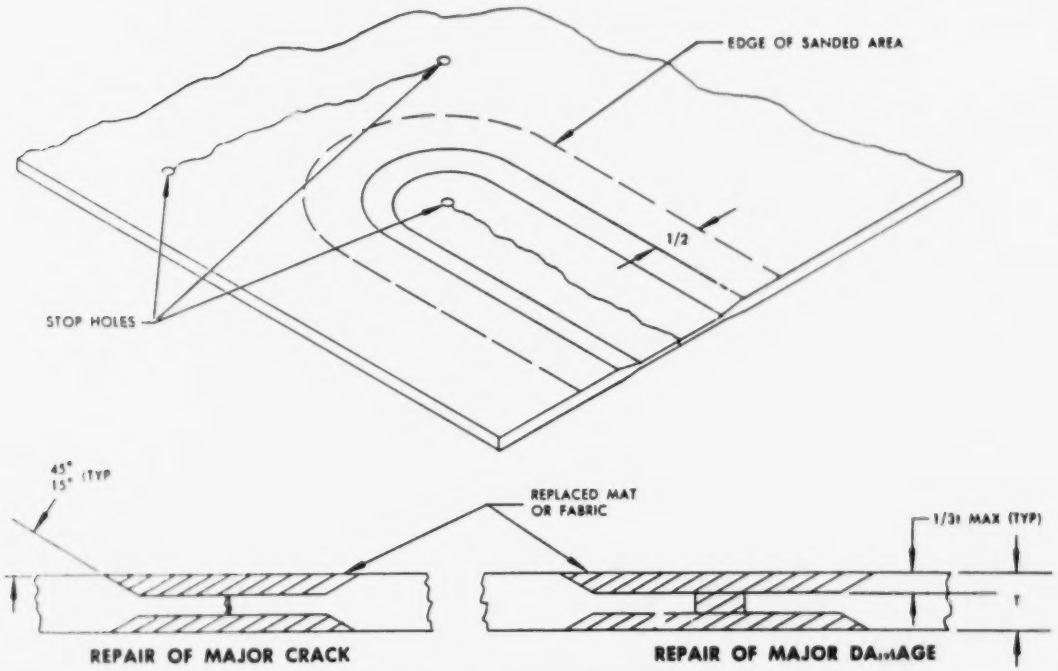
c. Cut the mat fiberglass to match the prepared area. Cut enough pieces of material to build up the beveled out area to its original contour.

d. Saturate each piece with resin.

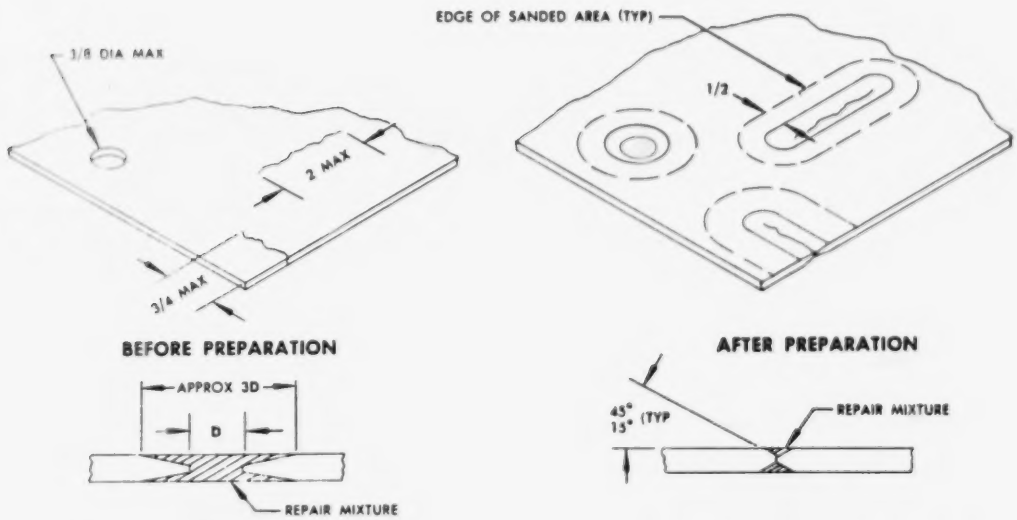
e. Insert the saturated mat fiberglass material into the repair area in the following steps:

(1) Do one side at a time.

(2) Cover each side with the precut PVA film.



REPAIR OF MAT MOLDED FIBERGLASS MAJOR DAMAGE



REPAIR OF MAT MOLDED FIBERGLASS MINOR DAMAGE

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Figure 2-8. Typical damage to mat molded parts.

(3) Place the prepared metal plate on each side as it is completed.

(4) Secure the repair in place by using the C-clamps. Tighten to a snug fit – never overtighten.

Curing Processes. When an air-cured resin mixture has been used, cure the repair part at room temperature. If, at room temperature (70°), the resin is slow to cure, apply a small amount of heat to help speed the curing. Remember, humidity affects the length of curing time.

When a heat-cured resin is used, there are several methods for applying heat. Any air-circulating oven capable of maintaining a temperature range between 220° F. to 250° F. can be used. Another method is the use of heat lamps. To maintain the correct surface temperature for curing when using heat lamps, use heat lamps of 250 to 350 watts or a battery of infrared lamps. A pyrometer and thermocouple wire are needed to maintain the correct surface temperature on the repair. A single lamp will adequately cure a repair up to 6 inches in diameter. Center the lamps over the repair at a distance of about 30 inches. Warmer or colder surrounding areas require adjustment of the heat lamps. Regardless of the method use, take care to insure even heating of the repaired area.

Quality Inspection. After the repaired section has been properly cured and cooled to room temperature, inspect it. As you check the repair, notice the short (various lengths from 1/2 to 2 inches) chopped strands of fiberglass embedded in the hard plastic. The fiberglass strands should be in a random pattern; the repair should have a hard surface and should give a metallic ring when struck with a coin (quarter) or a light aluminum hammer. If there is an indication of insufficient cure, additional heating and curing time is necessary. Check for large blisters, starved areas, and surface pits (pits should not be larger than 1/4 inch in diameter). Check the applicable technical order for permissible defect allowable.

Safety Precautions. General precautions to be followed in the shop include the use of face shield, goggles, rubber apron, rubber gloves, and care in mixing of resins. Do not inhale the fumes during the mixing procedures. Never mix the catalyst and promoter together; such a mixture may cause an explosion. Always mix the accelerator with the resin, then add the catalyst to that mixture. Remember, protection of the skin and the wearing of a respirator are important at all times when working with plastics. All chemicals should be identified, properly labeled, and placed in suitable containers. Be sure you have plenty of ventilation in the room you work in. The sanding and scraping on glass fabric laminates give off a fine dust that may cause skin irritation. Breathing an excessive amount of this dust may be injurious; therefore, observe precautions to protect your skin and respiration.

Exercises (819):

1. How should the area around a crack on a mat molded fiberglass panel be prepared prior to applying the repair materials?

2. What factor must you consider before preparing a resin mixture for a mat molded fiberglass repair?

3. How can you avoid moisture absorption when using resins that have been stored in a cool place?

4. What must you do to prevent skin irritations when handling resins?

5. How is a mat molded fiberglass repair held in place during the curing time?

6. How can you shorten the curing time for an air-cured resin mixture?

7. How should you set-up heat lamps to insure proper surface temperature?

8. If a coin test indicates an insufficient cure, what should you do?

2-3. Maintenance of Laminated Fiberglass Structures

820. State the purposes of the various tools, materials, and equipment needed when accomplishing repairs to laminated fiberglass structures and explain why more than one resin mixture is necessary.

Tools. Tools needed are scissors, spatula, knife, scribe, flexible straightedge, compass, squeegee or phenolic laminated material made of 1/8 or 5/16 inch thickness, approximately 3 or 4 inches square, with a radius on one end. The squeegee or phenolic material is used to smooth out the repair and to remove air bubbles and excessive resin in the impregnated cloth layers before curing the repair.

Materials. The repair of any laminated fiberglass structure requires you to use the approved materials as given in the technical order for the specific aircraft being repaired. Only authorized substitutions are recommended. The choice of resins to use for a specific repair will depend on the method of curing—either air or heat cured and on the type of resin used when the laminated structure was manufactured. To show you what is meant by the previous statement, take a look at the resin mixtures given in TO 1C-135(K)A-3-1 for fiberglass repairs.

Three resins are given, numbered 1 through 3. Resin mix No. 1 and No. 2 are polyester resins (light green in color) and resin mix No. 3 is an epoxy resin (brown in color). Resin mix No. 1 is a room temperature (70° F. to 125° F.) curing resin, and is used when a source of heat for curing is not available. Resin mix No. 2 is a heat cured (220° F.) resin and is preferrable to mix No. 1. Both resin mixtures No. 1 and No. 2 are to be used when the fiberglass component is fabricated from polyester resin. Resin mix No. 3 is to be used when epoxy resin was used in the manufacture of the part.

Other materials you will need are PVA film, cellophane tape. Duxseal or zinc chromate putty (paste) sealing compounds, safety goggles or face shield, rubber apron and gloves, cotton gloves, balance scales, cheesecloth, and clean rags.

Equipment. One piece of equipment you will need is a vacuum pump with airhose or vacuum tubing. A vacuum pump that has a minimum vacuum pressure of about 20 hg (inches of mercury) is practical for all purposes. This method, called vacuum bag pressure curing or vacuum bagging, is used (1) to cure resin in the repair of laminate fiberglass parts, (2) to apply uniform pressure to the fiberglass surface, (3) to reveal and remove air bubbles and excess resin, and (4) to provide a void-free surface. PVA film is sealed over a repair and air is removed; this causes atmospheric pressure to push the plastic film against the repair. The technical order will give you the amount of psi needed on the repair.

You will also need a pyrometer. A pyrometer, when connected to a thermocouple wire, indicates the surface temperature of the area being cured. It is important that the heat being applied to a fiberglass repair be within the specific temperatures recommended by the TO. When maximum temperatures are exceeded, damage usually results not only to the repair area, but also the surrounding areas. When the temperature is not high enough, the repaired area will not cure satisfactorily.

Exercises (820):

1. What is the purpose of a phenolic squeegee?
2. What is the purpose of having more than one type of resin mixture for repairing laminated fiberglass parts?
3. What is the purpose for using a vacuum pump when repairing laminated fiberglass parts?
4. What purpose does a pyrometer serve when repairing laminated fiberglass parts?

821. Differentiate between the methods used to remove damaged plies from laminated fiberglass parts.

A repair to laminated fiberglass in which the cloth plies are damaged is considered a major repair. Damage through one or more plies or completely through the part will require you to remove the damaged portion and replace with approved materials in such a manner that normal stresses can be carried over the area. Two methods are used to remove the plies—the step-joint method and scarf method.

Step-Joint Method. The step-joint method is accomplished in the following manner:

a. Outline the damaged area to the shape of a circle, square, or rectangle (round all corners of a square or rectangle).

b. Count the number of damaged skin plies and subtract one ply. Multiply by 1 inch (four plies less one equals three plies times 1 inch, equals 3 inches). Extend the side you have outlined around repair (3 inches).

c. Use a sharp knife or specially prepared cutter and cut along the outer line. Cut through the first ply only. Do not cut into the second ply as it can weaken the repair.

d. Remove the cut outer ply by inserting a knife or putty knife under a corner. Begin prying loose until it is removed.

e. Scribe on the exposed ply a similar outline reducing the dimension 1 inch. Remove the ply as you did the first ply.

f. Repeat the procedures until all damaged plies are removed.

g. Lightly sand exposed plies and clean surfaces with MEK. Be sure to thoroughly dry the surfaces.

Section A of figure 2-9, shows a side view of how the cutout should look after removing the damaged plies from one side. Section B of figure 2-9, shows how the cutout is made when a damage is completely through the laminated structure. When damage extends through the plies, all the damaged plies may be

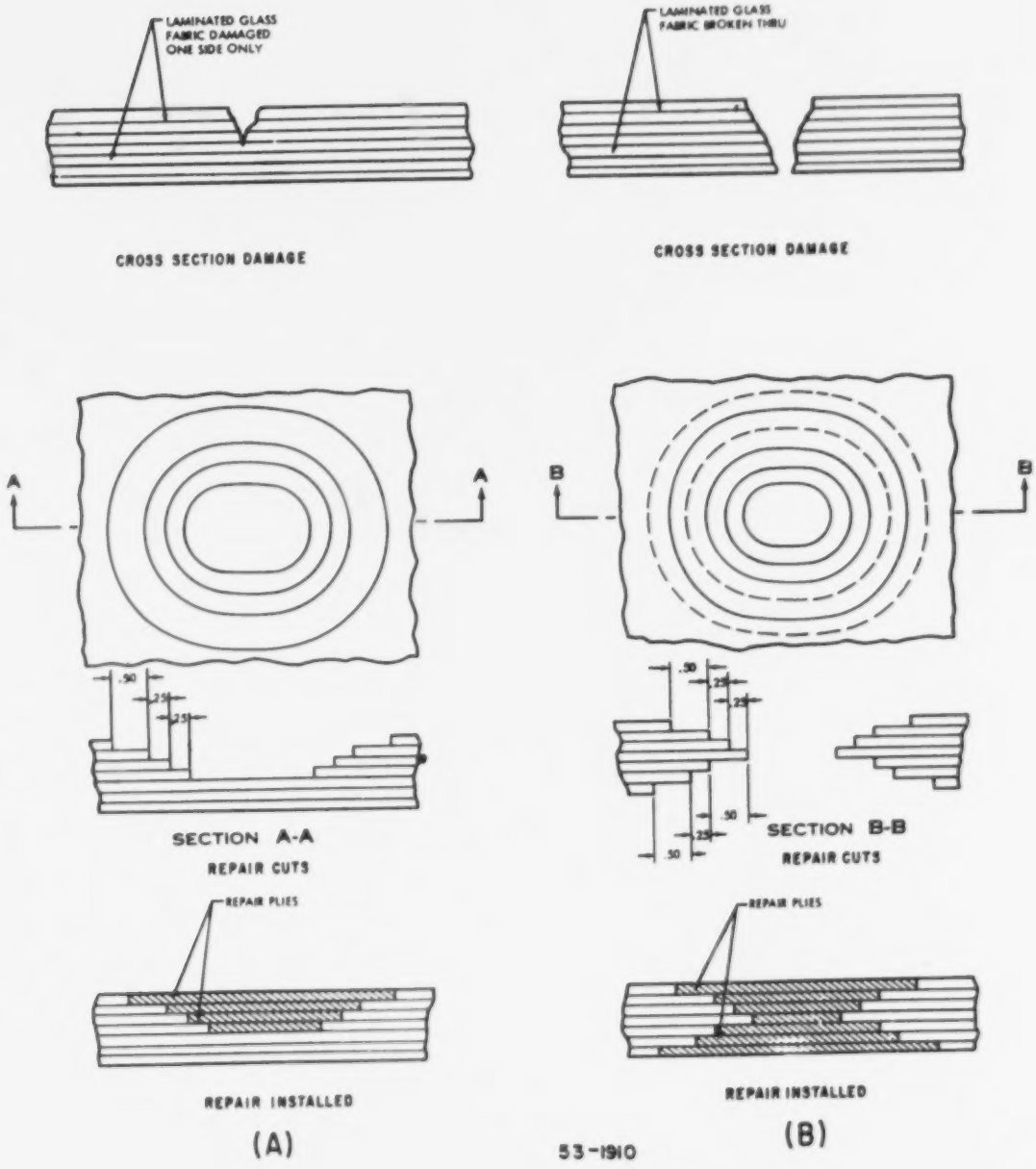

Figure 2-9. Step-joint method of ply removal.

removed in one operation by use of a penumatic circular saw. The saw must be equipped with a guide for adjusting the depth of the cut. After all the damaged plies have been removed, the plies around the cut-out are then stepped off as earlier described. From an electrical standpoint the step-joint method produces a more nearly homogenous patch and is normally the preferred technique of ply removal.

Scarp Method. The scarf method requires the damaged plies to be feathered as far back as possible. For small repair up to 3 or 4 inches, the scarf method is normally used; especially if the facing is constructed of a thin weave of glass cloth that would make it difficult to peel off.

The scarf method consists of sanding out the damaged face plies into a circular or oval disk shaped cutout. Caution must be exercised to avoid damage to the opposite facing. The damaged plies should be scarfed back carefully to a distance of at least 50 times the total face ply thickness. You must perform the

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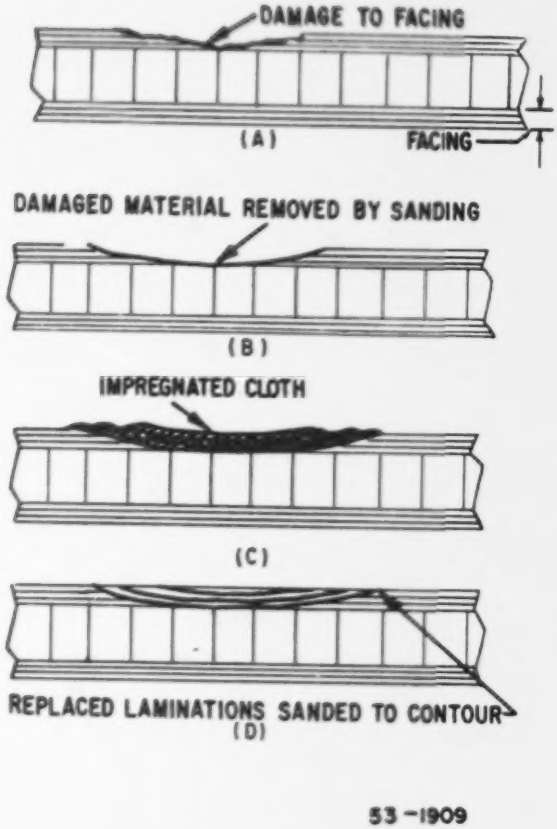

Figure 2-10. Scarf method of ply removal.

scarfing method very accurately to produce a uniform taper. It is best to make a few practice attempts on scrap material before you start on the repair part. Figure 2-10, section B, shows how a scarf cutout should look after sanding.

Exercises (821):

1. How do the tools used to make a step-joint cutout differ from those used to make a scarf cutout?

2. When would you use the scarf method over the step-joint method of ply removal?

3. Explain how the factors used when determining the cutout sizes differ between the scarf and step-joint methods.

822. Given related information, explain factors used to select the appropriate type of fiberglass repair cloth.

Characteristics of Fiberglass Cloth. Earlier objectives mentioned the use of chopped fiber mat as a reinforcement in plastic. Fibrous glass reinforcement also comes in the form of woven fabric, continuous fiber mat, wrap, or roving. The specific form used depends upon the application involved and the strength properties required. Glass fabrics are made from either continuous filament or stable fiber yarns. For aircraft applications, glass fabric made from continuous filament yarns is used almost exclusively. Fabrics are woven to have different strength properties in two directions–that is, parallel and perpendicular to the warp direction.

Fiberglass cloth is used for reinforcement because of its structural strength properties. There are approximately six characteristics that you must consider when using fiberglass cloth for repairs.

a. The thickness of fiberglass cloth varies from 0.0010 to 0.38 inch thick.

b. The weight of fiberglass cloth is computed by the square yard and varies from 1 ounce to 2 pounds per square yard.

c. Note the weave types. There are five commonly used weave patterns, as shown in figure 2-11.

d. Many yarn sizes and twists are in use and are determined by weight and thickness of the fabric.

e. A finish is usually applied after the glass cloth has received its initial treatment. Each glass fabric has a specific finish that meets the requirements of the resins to be used.

f. Another structural property of fiberglass cloth to consider is the strength of the fiberglass strands of which it is constructed. (See fig. 2-12.)

A finish is applied to the glass cloth without regard to its application. The glass filaments are very susceptible to abrasion by one another. To prevent the abrasion a lubricant is applied immediately after forming. The filaments in the strands are bonded together by a coupling agent known as a finish. The coupling agent (finish) is applied to provide adhesion for the resin. The reason for the finish is that resins do not adhere to the glass well; thus the treatment must act as a lubrication and bonding agent between the filaments. Two general types of finishes are used: silanes and chromes. The choice of which finish is used is determined by the strength required and the type of resin to be used.

Types of Fiberglass Cloth Finishes. There are many different finishes for fiberglass, each of which is used for different conditions and circumstances and is normally applied after a heat-cleaning process.

a. T-31 finish. T-31 is saturated with a silane type chemical and carefully cured. It is used where polyester, epoxy, phenolic, and melamine resins are to be the bonding resins.

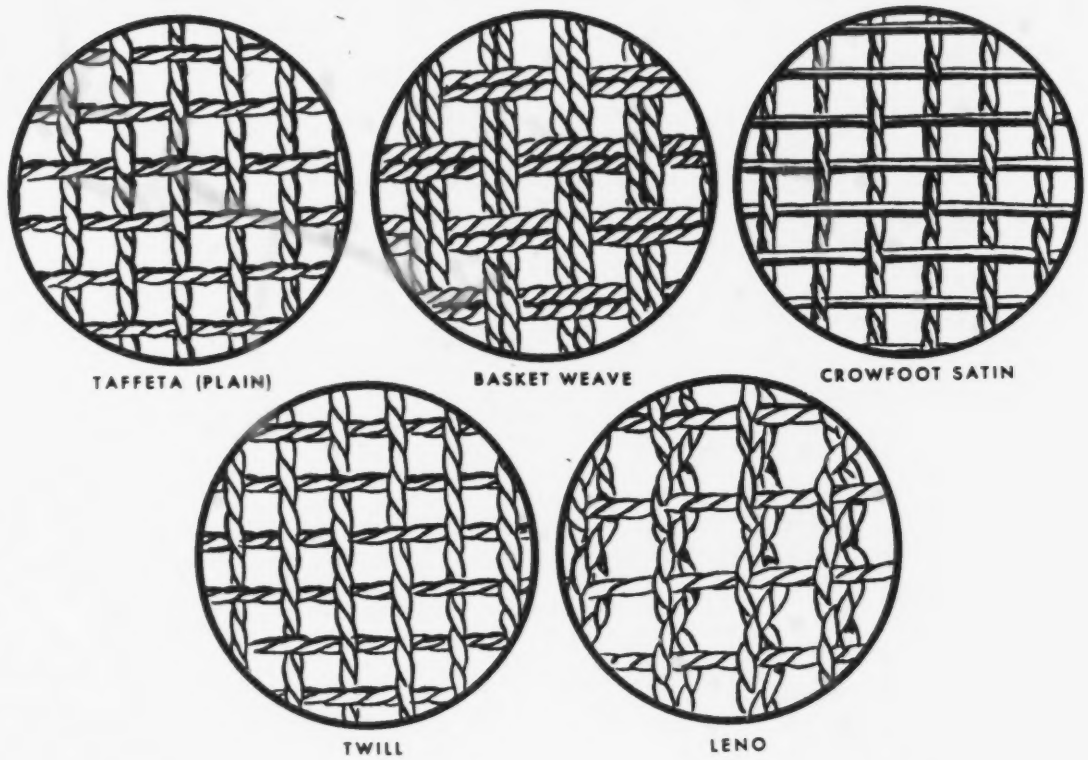

Figure 2-11. Weave pattern for fiberglass cloth.

b. 108 Finish. The 108 finish is used where no heat-treatment or heat-cleaning is necessary. The fabric is dipped in a water emulsion of silicone oil and placed in a drying oven. This finish is used to prevent moisture from entering the fabric through the exposed cut edges. Moisture causes deterioration of the fabric's wet strength capability. This finish is also used on fabrics to be coated with vinyl compounds or natural and synthetic rubbers.

c. 111 Finish. This finish consists of a low temperature partial removal of the fabric yarn sizing, during which some of the oils and starch vaporizes rapidly and the starch that is left is caramelized. It has a tan color and is used primarily in melamine laminates.

d. 114 Finish. After heat cleaning, the fabric is saturated with methacrylate chromic chloride and dried. This finish is for use with polyester laminates where maximum dry strength and retention of wet strength are not necessary factors.

e. 136 Finish. This finish is heat-cleaned and then saturated with silane type chemical. Then it is dried under controlled conditions that leave a vinyl triethoxysilane on the glass surface. The primary use of this finish is for silane and polyester laminates; it has excellent dry and wet strength properties.

f. A-172 Finish. After heat-cleaning, the fabric is immersed until saturated with silane type chemical and dried under controlled conditions. Vinyl-triethoxysilane remains on the surface of the glass. This finish is used with polyester resins and meets MIL-P-8013-B and MIL-F-9084-A specifications.

g. 210 Finish. This finish requires a special method that removes the oil and starch binder to a level of 0.12 percent or less.

h. 1-516 Finish. This finish is similar to type 111 finish except it has a 0.1 to 0.2 percent further ignition loss. This increases the physical and electrical properties above the 111 finish.

i. A-1100 Finish. The fabric is saturated with aminetype vinylsilane and dried. A-100 is used with phenolic, epoxy, and melamine resins. Laminates having this finish meet Specifications MIL-Rf19299 and MIL-R-9300-A and are used with high-temperature phenolics.

j. GARAN RS-49 Finish. The fabric receives a heat-cleaning finish and is then run through a silane type chemical. After drying, vinyl-triethoxysilane remains on the surface of the glass. This finish meets Specifications MIL-P-8013-B and MIL-F-9084-A.

Fabric (Type)	Construction (Warp & Fill)	Weight Oz/sq yd	Thickness (inches)	Breaking Strength (lbs/inch) Warp	Fill	Roll Length (yards)
120	60 x 58	3.16	.004	125	120	250
128	42 x 32	5.92	.007	250	200	250
181	57 x 54	8.74	.009	340	330	125

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Figure 2-12. Strength of fiberglass cloth.

k. VOLAN-A Finish. After receiving heat-cleaning treatment, the glass is saturated with methacrylate chromic chloride so that the chrome content of the finished fabric is between 0.03 and 0.05 percent. It is washed after the methacrylate chromic chloride is cured to remove the soluble chlorides that are formed. This finish is used with polyester, epoxy, and phenolic laminates that require good wet and dry strength properties. Polyester laminates meet Military Specifications MIL-P-8013-B and MIL-F-9084-A.

Exercises (822):

1. When selecting fiberglass cloth for a repair, why is it important to consider the direction of the weave?

2. Why is it necessary that fiberglass cloth have a finish?

3. Before you choose between fiberglass cloth having either finish of silanes or chromes, what must you know?

4. What factors would cause you to select a fiberglass cloth with a VOLAN-A finish?

823. Given work procedures related to replacing laminated fiberglass facings, match the work procedures to a specific type of removal cutout.

The cutout method used to remove damaged laminated fiberglass plies will directly affect the procedures you use in fabricating and replacing the damaged plies. Typical procedures are given in the following paragraphs for replacing plies for step-joint and scarf cutouts.

Step-Joint Replacement. When damaged fiberglass plies have been removed by the step-joint removal method, the following steps restore the structural and electrical qualities of the part being repaired.

- Step 1. Lightly sand exposed plies and clean surfaces using MEK and allow it to dry thoroughly before starting replacement.
- Step 2. Cut replacement patches from glass cloth the same thickness, warp, fill direction, and style of original material. Make them larger than the area they are to fit. Cut two pieces of cellophane or PVA film approximately 2 inches larger than the patches for each step.
- Step 3. Starting with the smallest or innermost patch, impregnate the glass cloth with catalyzed resin -that is, 45 to 50 percent resin (weight of resin equal to weight of dry glass cloth comprises 50 percent resin content). Place it between two sheets of cellophane or PVA film. Cut with scissors to the exact size you need for this step in the repair. This method prevents the fraying of cloth edges. Templates can be made from cardboard to correct size for each step in the repair.
- Step 4. Fit the innermost patch (smallest) to the area. The pieces of fabric are laid in place by first removing the PVA film from one side of the fabric. Place the exposed fabric in position on the repair. Then remove the second piece of PVA film. The edges are to be butted to the existing bond ply. Be sure the weave direction of replacement ply runs in the same direction as the existing plies; otherwise, strength will be reduced.
- Step 5. Place a sheet of cellophane or PVA film over the replacement ply. Work out all of the air bubbles with a squeegee or phenolic block. When the ply is void-free and smooth, cure in accordance with the manufacturer's instructions.

• Step 6. Lightly sand the cured repair ply surface. Now you can place the next cloth ply in the same manner as the first.

When the repair has cured, lightly sand the surface as much as is necessary to obtain a smooth surface and to remove excess cured resin. On solid laminates, when damage extends completely through all plies, remove one-half of the damaged face plies from one side and complete the replacement, then repeat the same procedures on the opposite side of the damaged area.

Scarfed Cutout Replacement. The method used to replace plies into the scarfed cutout area will affect the sequence of plies replacement. One method is similar to the step-joint method where smaller plies are inserted first, with increasingly larger plies being inserted. The other method is directly opposite in that the largest ply is inserted first, then the smaller plies. Section C of figure 2-10 illustrates this method.

When using the replacement method of smaller ply to larger ply insertion, the first ply should overlay the smallest area of the cutout by at least 1/2 of an inch. Adding an additional 1/2 of an inch overlap, to the next ply, fit the next larger ply and so on, until the buildup is complete. When using the opposite method, the first ply is cut so that at least 1/4 of an inch overlaps the outer edges of the cutout area. Each additional ply should be 1/2 inch smaller, until the necessary buildup is completed.

Regardless of the method used to insert replacement plies, prepare the plies as stated in the step-joint method (step 3). When all of the replacement plies are prepared, lightly sand the exposed plies on the repair part and clean with MEK, allowing the surface to dry before starting the ply buildup. Once the MEK drys, coat the sanded surfaces with a coat of catalyzed resin. Having brushed the sanded surfaces with resin, fit the replacement plies based on the replacement method being used. At this point, follow the techniques covered for the step-joint method in steps 5 and 6. When the repair has cured, sand the surface of the repaired area to match the contour of the part being repaired. (See sec. D of fig. 2-10.)

Exercises (823):
If a work procedure described in the following listing is used when making a step-joint cutout, place the number (1) in the space. If the work procedure is used when making a scarf cutout, place the number (2) in the space provided. If the work procedure applies to both methods, place both the numbers (1) and (2) in the space provided.

____ 1. Cut replacement plies to the exact size of the cutout area.
____ 2. Cut PVA film approximately 2 inches longer than the replacement plies.
____ 3. Insert largest replacement ply first.
____ 4. Edges of replacement plies are butted to the existing bonded plies.
____ 5. Cure one replacement ply before applying the remaining plies.
____ 6. Sand replacement plies to match contour of the repaired part.
____ 7. Each ply should overlay the outer edge of the cutout area.
____ 8. Smallest ply is always inserted first.
____ 9. Repairs are completed on one side before the opposite side is repaired.
____ 10. When the smallest replacement ply is inserted, it should overlap the smallest area of the cutout area by at least 1/2 of an inch.

824. Describe procedures or specifications for applying vacuum pressure to a laminated fiberglass repair.

Vacuum Bag Procedures. To apply uniform pressure to laminated fiberglass repairs, vacuum pressure curing is used. It is important that correct procedures are used to insure that the repair material is tightly bonded to the structure and the desired contour is produced. Figure 2-13 shows the complete setup followed when applying vacuum pressure to a fiberglass repair. The following steps describe the process of setting up this method to obtain a void-free repair.

• Step 1. Once the repair materials are positioned in the cutout area, coat the surface around the repair with a suitable paste wax and allow it to dry. Maintain a distance of 1/2 inch between the repair area and the wax coating. The wax acts as a parting agent when removing the duxseal barrier.

• Step 2. Using your hands, mold enough Duxseal (a soft clay like material) into a rope-like form and completely circle the repair area with it. The Duxseal should be about the size of your thumb, and be placed at least 3 inches from the outer ply of the repair area.

• Step 3. Place a breather strip made of felt, 1/4 inch thick and 1 inch wide, or a flexible coil spring (screen door spring) around the entire repair. Place it approximately 1 inch from the wet laminate. Clothes line rope, or rolled gauze or cheesecloth may also be used.

• Step 4. Cut from a sheet of PVA film a piece to conform to the repair area and to extend approximately 1 inch beyond the strip of Duxseal or zinc chromate putty.

• Step 5. Place the open end of the aluminum tubing (which is attached to the vacuum hose) beyond the Duxseal or zinc chromate putty to the edge of the spring or felt strip.

• Step 6. Pack the putty around the tubing. When the vacuum line does not have a moisture or resin trap, you must place several layers of cheesecloth over the open end of the aluminum tubing. This will prevent resin, putty, or other foreign material from entering the vacuum line to the pump.

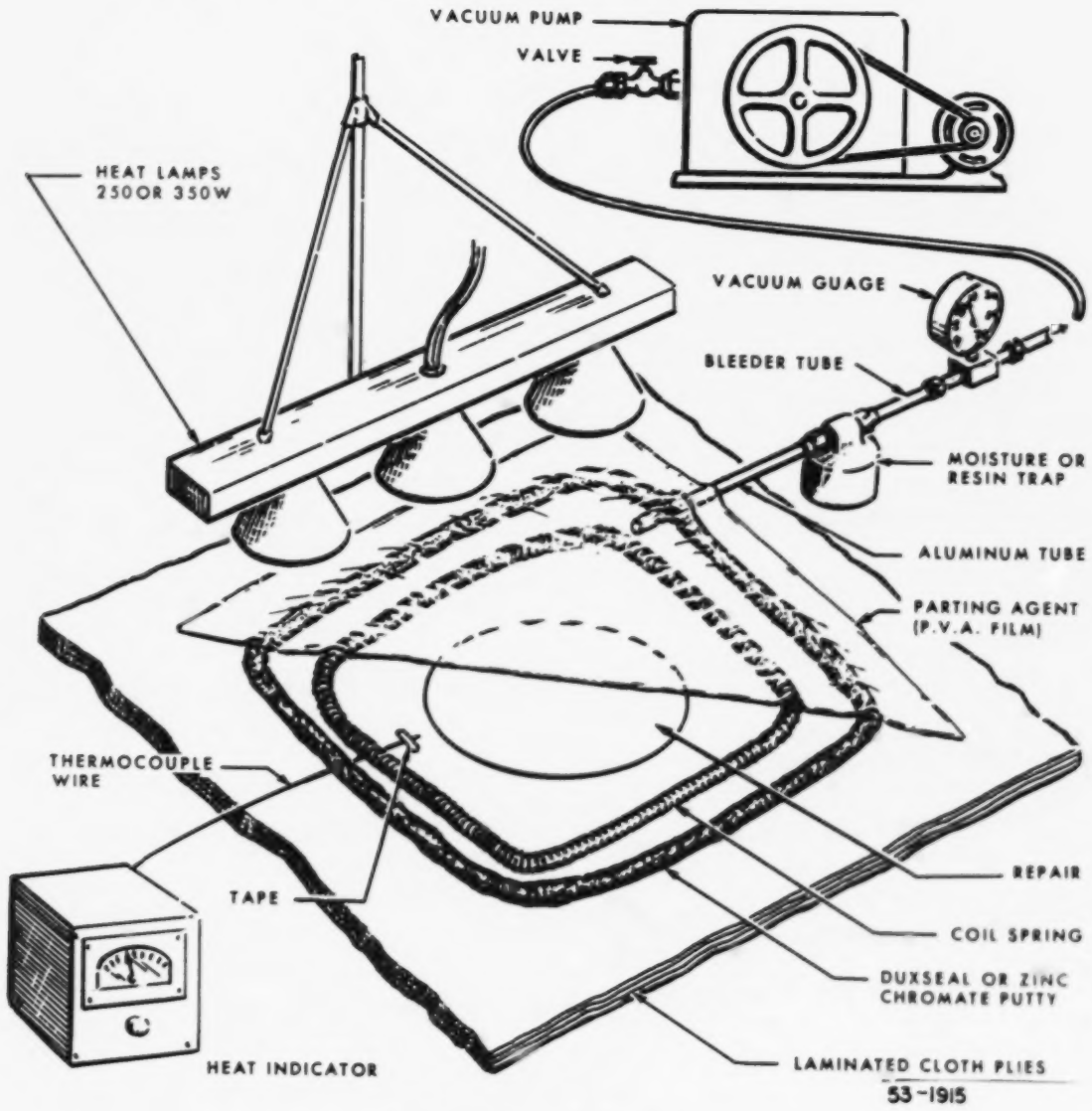

Figure 2-13. Vacuum bag pressure curing.

• Step 7. When using heat to cure a repair, place a thermocouple wire (peel covering from wire approximately 1/2 inch from end) approximately 1/2 inch from wet laminate. Tape the wire to the surface with mylar or cellophane tape. Imbed the wire into the Duxseal or zinc chromate putty to prevent air leakage along the wire. Hook the thermocouple wire to a heat indicator such as a pyrometer.

• Step 8. Place the PVA film over the repair (wet laminate) and press film into the Duxseal or zinc chromate putty.

• Step 9. Apply vacuum slowly to the repair. The PVA film will collapse or flatten over the repair area. Check for leaks around the putty. Stop any leakage of air to prevent loss of vacuum.

• Step 10. Work out the wrinkles in PVA film with a squeegee or phenolic block. Using the radius end, wipe out all air bubbles and excess resin. Start approximately at the center and sweep toward the edge of repair. Use a slow motion to sweep out the bubbles along with the resin. Squeegees made from teflon material or flexible rubber are the recommended. The dimensions of the squeegees may vary, depending on the contour of the work surface. Rubber squeegees approximately 4 x 6 x 1/2-inch are satisfactory for most applications. If rubber squeegees are used, the PVA surface should be coated with a light film of lubricating oil so that frictional drag is reduced. When teflon squeegees are used, lubrication of the PVA is not necessary.

• Step 11. When all air bubbles and excess resin are removed, stop: further wiping will create air or vapor voids. This will be indicated by a whitening or loss of transparency.

• Step 12. If you puncture the film while wiping, repair with transparent tape. Remove all trapped air from the repair again by wiping the surface.

• Step 13. Maintain the vacuum pressure until the repair is cured. A vacuum pressure between 15 to 28 inches of mercury should be maintained. Too much vacuum pressure will squeeze too much resin out of the wet laminates. Drawing too little vacuum will not produce the desired pressure to force the wet laminates tightly against the structure. If sufficient pressure isn't maintained, ply separation or delamination will result.

Vacuum Materials. When selecting materials, especially the parting agent film, the temperature at which the repair is to be cured must be known. Polyvinyl alcohol (PVA) film is ideal when the bonding temperature does not exceed 250° F. PVA film has very high tear resistance and may be heat sealed effectively. When the bond temperature is not above 180° F., polyvinyl chloride film can be used. For temperatures up to 450° F., a polyvinyl fluoride film is used. These three types of films are available in a variety of weights and widths.

Exercises (824):

1. Describe the size and the positioning of the Duxseal barrier used in a vacuum pressure setup during a fiberglass repair.

2. Describe the size and positioning of the breather strip used in a vacuum pressure setup during a fiberglass repair.

3. How large should the PVA film be cut for a fiberglass repair when vacuum pressure is being used?

4. Where should the thermocouple wire be placed to insure an accurate indication of surface temperature?

5. Once the vacuum pressure is applied, describe how air bubbles and excessive resin should be removed from the repair area using a teflon squeegee.

6. When would it be necessary to apply a light coat of oil to the outer surface of the PVA used during a vacuum setup?

7. If plies are delaminated after the repair has been cured using vacuum pressure, what is usually the cause?

8. When would you use polyvinyl fluoride film in place of PVA film?

825. Given repair situations related to laminated fiberglass parts, determine the correct sequence of repair procedures to follow.

Minor Repairs. Minor or Class I repairs, for example, scars, scratches, surface abrasions, or minor rain erosion not penetrating through the first ply facing or fiberglass cloth will be repaired as follows:

a. Clean damaged area thoroughly and carefully, using a clean cloth saturated with methyl ethyl ketone (MEK), Specification TT-M-261.

b. Lightly sand the damaged area using number 280 grit sandpaper. Clean the sanded area thoroughly using MEK. Make sure that moisture and solvents are completely removed to prevent their inhibiting the cure of the resin.

c. Mix resin according to the applicable technical order and apply one or two coats of catalyzed resin to the abraided surface. Fill to level of surface.

d. Cut a piece of cellophane or PVA film approximately 2 or 3 inches larger than the resin-coated surface and lay it on the repair area. The film will provide a smooth surface beneath which the resin can cure.

e. Tape the film in place and work out all air bubbles and excessive resin. You can vacuum bag the area if you so desire. Cure the repair as given in the specific technical order.

f. After the resin has cured, remove the film. Excess resin can be sanded to surface level.

g. When a rain erosion coating is removed to accomplish a repair, replace in accordance with the technical order procedures.

Skin Delamination. A skin *delamination* is a separation between two or more plies of fiberglass. Delamination is caused by improper bonding, the part being dropped, or the part being struck by a heavy object. Repair a skin delamination as follows: (refer to fig. 2-14).

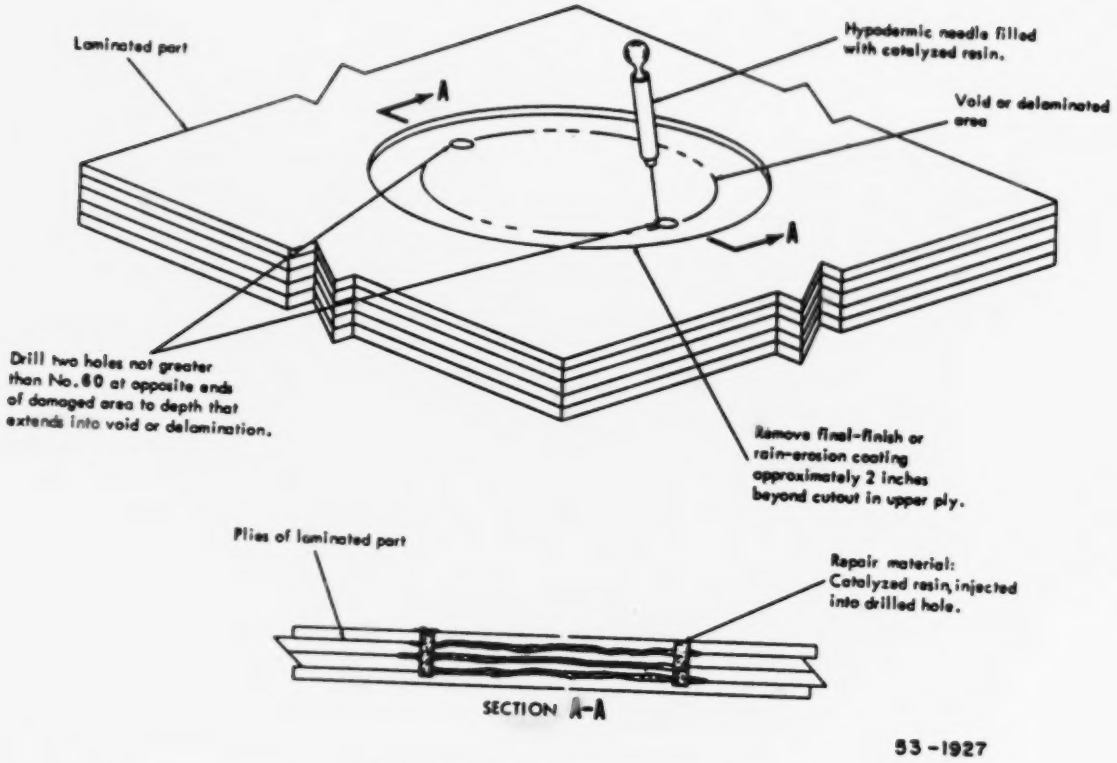
Laminated part
Hypodermic needle filled with catalyzed resin.
Void or delaminated area
A
A
Drill two holes not greater than No. 60 at opposite ends of damaged area to depth that extends into void or delamination.
Remove final-finish or rain-erosion coating approximately 2 inches beyond cutout in upper ply.
Plies of laminated part
Repair material: Catalyzed resin injected into drilled hole.
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Figure 2-14. Delamination repair procedures.

a. Drill a hole into the delamination area using a number 60 drill bit.

b. Use a hypodermic syringe and needle and inject resin slowly into the delaminated area. When injecting resin and air entrapment occurs, drill additional holes. Inject resin until it flows freely from the drilled holes. (Sec. A-A of fig. 2-14.)

c. After the void is completely filled, bring the delaminated area down to the proper thickness. Work out excess resin from between the layers of laminate. Cover with cellophane or PVA film.

d. Apply pressure to the area using C-clamps or vacuum bag and cure according to the applicable technical order.

Exercises (825):

1. Arrange the following abbreviated work procedures for a minor repair to a laminated fiberglass part in the proper sequence.
   a. Sand surface of repair level with contour of repaired part.
   b. Cut PVA to approximately 3 inches larger than the repair area.
   c. Clean damaged area using MEK.
   d. Remove PVA film from repair area.
   e. Mix resin according to the applicable specifications.
   f. Lightly sand the damaged area using 280 grit sandpaper.
   g. Replace rain erosion coating.

h. Work out excessive resin and air bubbles.

2. Arrange the following abbreviated work procedures for repairing a delaminated facing on a laminated fiberglass part.
   a. Apply pressure and cure delaminated area.

   b. Inject resin into delaminated area.

   c. Drill #60 holes in delaminated area.

   d. Cover area with PVA.

   e. Work out excess resin from between the layers of laminates.

826. Specify whether given statements about the inspection criteria used after repairing laminated fiberglass structures are in agreement with accepted guidelines.

Quality Inspection. After a repair is completed by you, it is inspected for good workmanship. Repairs are inspected by shop personnel to insure compliance with the requirements of the technical order. The inspection consists only of a visual or metallic ring test. Minor defects are acceptable when they do not exceed specific specifications and are within the allowable limits.

a. The laminate must be within the tolerance of the drawings and specifications and of uniform workmanship.

b. Each layer or fabric shall butt up to the existing ply, unless otherwise specified, to form a continuous layer.

c. There shall be no cracks in the facing or ply repair.

d. Wrinkles are not allowed. They are defined as a raised fold of cloth in a ply and reduce tensile and compressive strength.

e. Holes that penetrate the first layer of glass cloth (ply) are not acceptable.

f. Blisters are areas in which there is a lack of bond between any two plies of glass cloth in a repaired laminate. Internal blisters or styrene bubbles less than 0.05-inch diameter are permitted in the two outer layers when they have a "wet out" appearance; however, blisters of 1/4-inch diameter and smaller and 4 inches apart are allowed in the other layers.

g. Delamination is an unbonded area and not allowed if larger than the sizes and quantity specified in the applicable aircraft technical order or given in TO 1-1-24. Delaminated areas will have a whitish appearance through translucent plies. When the plies are not translucent, you can detect delamination by lightly tapping the surface with a blunt instrument or a 25-cent piece (tap lightly so as not to damage the part). The sound of the tapping will be a clear metallic ring over a well-bonded area and a dull thudding sound over a delaminated area. A large delaminated area is soft, flexible, or of balloon characteristic and can be detected by visual means or by the pressure of your thumb or hand on the suspected area.

h. Voids or pores extending into the glass cloth of the outer ply are not acceptable. Small pits are acceptable in the resin seal coat. Laminates containing high percentages of voids tend to absorb moisture and affect the electrical characteristics of the radar system's operation.

i. No foreign matter or substances (metal particles, etc.) are allowed. They can cut down the effectiveness of the radar system.

j. In a good repair, the weave of the glass cloth is barely visible through the resin; when you cannot see the weave you have an excessive amount of resin. The excess resin can cause degrading of a radar system.

k. Starved areas are not allowed. A starved area is one in which the glass cloth is not impregnated with resin.

Exercises (826):
Indicate, in the space provided in front of each statement, whether the statement is true or false by placing the letter T or F. NOTE: "true" statements here are those that express or imply agreement with accepted guidelines.

____ 1. Wrinkles are allowed on the surface ply of fiberglass repairs provided they are parallel to widest side of the cutout.
____ 2. Holes that penetrate the first layer of glass cloth are not acceptable.
____ 3. Internal blisters of less than 0.050 of an inch in diameter are permitted in the two outer layers when they have a "wet out" appearance.
____ 4. Small pits are not acceptable in the resin seal coat.
____ 5. Starved areas are permitted provided the area is sandwiched between two bonded plies.
____ 6. A large soft, flexible area is characteristic of a delaminated area.
____ 7. Areas of excessive resin are not permitted.

—— 8. Cracks less than 1/4 of an inch in length are allowable.
—— 9. When you can barely see the weave of the glass cloth, the resin mixture is correct.
—— 10. Voids or pores, regardless of size, are not acceptable.

2-4. Maintenance of Fiberglass Honeycomb Radomes

Repairs given in this section are typical field repairs. You should always select the applicable technical order for the specific aircraft before attempting any repair on aircraft's radome. The repair techniques given in this section are simple; even so, if you have little or no experience with the materials and techniques involved in making repairs to fiberglass radomes, you may have difficulty in immediately interpreting the procedures and in making acceptable repairs during their first attempt. It is recommended that you practice on unserviceable parts and be certified on each type of repair prior to working on serviceable aircraft.

827. Given radome handling and storage situations, specify the practice, fixture or requirements that would prevent damage.

Radomes are very susceptible to damage during all handling operations. Damage is sometimes minute and invisible, but, when exposed to vibration, stress or liquids (water and oil), deterioration follows. To reduce the possibility of your causing damage and costly repair work, follow the practices outlined in the following paragraphs.

Handling Radomes. Handle radomes with special care. Avoid placing radomes upon rough surfaces and among metal parts. Maintenance work stands carelessly pushed into radomes is a common source of radome damage. Take caution to prevent such damage as well as damage caused by careless handling after the radome has been removed from the aircraft. Place radomes in padded dollies or padded racks for transporting when the radomes are not crated or installed on an aircraft.

Installing Radomes. The ability of fiberglass constructed items such as boats to withstand rough treatment has led to the mistaken belief that radomes may be handled haphazardly. This is an erroneous and costly assumption. A radome is a fragile item that requires special care at all times.

Correct radome installation procedures begin with the uncrating operation. Before uncrating a radome, provide a clean padded surface to set the radome on. Adhere closely to the instructions for opening the radome shipping container. This will prevent damages that could be inflicted to the radome by protruding nails, bolts, staples or other sharp objects. Installation instructions of the applicable aircraft manual shall be closely adhered to when installing radomes on aircraft. Should sanding or grinding of the radome be required to fit mounting frame, the sanded surfaces should be classified as Class I repair and reworked accordingly. The laminate sandwich fluted core and filament-wound construction of radomes provides a structure that will withstand heavy loads and stresses when applied to the over-all radome. It is emphasized that localized pressures and sharp impacts can result in delamination of the layers of fiberglass construction.

Avoid hammering or exerting unnecessary pressure on radomes with the hands or any other object, particularly over the honeycomb. Greater pressures may be exerted over the solid laminate edgeband area for the purpose of fastening the radome in place.

Storing Radomes. Store reparable as well as serviceable radomes in a dry area, suitable crates or padded racks, and supported from mounting holes. Stacking radomes directly upon each other is prohibited. To prolong the life of a radome, never expose it to weather when it is not installed on an aircraft. Apply no protective coating to radome surfaces for prevention of scratching or marring during storage. Protect surfaces by covering them with paper or similar material. Prime air materiel area will determine and approve of any exceptions to this policy.

Exercises (827):

1. When radomes are not crated or installed on an aircraft, what type of holding fixtures should be used?

2. What part of a radome should be used when pressure is needed to install a radome in place?

3. State four requirements that must be considered when storing radomes.

828. Identify specific characteristics and types of material used to construct fiberglass honeycomb radomes.

Facing Materials. Glass cloth reinforced plastic laminates are most commonly used for construction of the radome facings. Glass cloth that is "wet-laminated" in place with the laminating resin serves to give the facing acceptable rigidity and also to form the bond to the core. Glass cloth, due to its relatively high strength and versatility, is used almost exclusively as a reinforcing material in plastic facings for radome

"sandwiches" in aircraft. It has excellent electrical characteristics. Glass cloth reinforced facings are commonly "wet-laminated" in place by laying them up one layer of cloth at a time after the cloth has been impregnated with a laminating resin.

Honeycomb Core Material. Requirements of greater importance than strength properties normally dictate the choice of core materials for radomes. Properties such as the dielectric constant, the loss tangent, and an exceedingly low rate of moisture absorption are of greatest importance with strength being of secondary importance except for large radomes. The core material will be of the type and thickness specified in the applicable design drawing. One of the most common core materials in current radome construction is glass cloth impregnated with a polyester or a combination of nylon and phenolic resin and fabricated into a honeycomb structure in a variety of cell sizes from 3/16 inch to 3/8 inch in diameter, Specification MIL-C-8073. The material is normally fabricated in blocks that are later cut on a band saw to slices of the exact thickness desired, or it may be procured precut to the proper thickness.

Radome Type Resins. Resins used in laminating the facings of radome type sandwiches are normally of the low pressure laminating types conforming to Specification MIL-R-7575C (polyester) and MIL-R-9300B (epoxy). These resins are normally supplied as a liquid varying in viscosity from a water-like consistency to a thick syrup and are available commercially from several manufacturers.

Cure or polymerization of polyester resins is aided by the use of a catalyst, usually benzoyl peroxide, and in most cases at a relatively high temperature. If room temperature cure is to be used, promoter must be added to the resin BEFORE the peroxide catalyst is added to the mixture. The procedures and materials for catalyzing and curing resins shall be in accordance with the manufacturer's instruction sheet when specific instructions are not supplied in Air Force technical data.

Exercises (828):

1. What characteristics of glass cloth are the reasons that glass cloth is used almost exclusively as facing material for radomes?

2. What are the most common core materials used in current honeycomb radomes?

3. What types of resins are grouped in Specification MIL-R-7575C?

4. What types of resins are grouped in Specification MIL-R-9300B?

5. Replacement honeycomb core materials are available from the manufacturer in what configuration types?

829. Specify whether given statements concerning the repair of radomes are in agreement with accepted guidelines.

Principles of Repair. Repair procedures for radomes are developed with the objective of equaling as nearly as possible the electrical and strength properties of the original part with a minimum of increase in weight. This can only be accomplished by repairing damaged parts with approved materials and working techniques. In order to eliminate dangerous stress concentration, avoid abrupt changes in cross sectional areas by tapering joints, by making small patches round or oval shaped instead of rectangular, and by rounding the corners of all repairs. Smoothness of outside surface of high speed aircraft is a necessity for proper performance; consequently, avoid patches that project above the original surface. Uniformity in thickness of core, facings, and density and cell size of core are exceedingly important because any deviations will hinder the function of proper radar reception and transmission. Repairs of punctured facings, delaminations, oil contamination, and fractured cores in all areas necessitate removal of all damaged material, followed by its replacement with approved type of materials and in the same thickness as the original and obtaining a "void-free" laminate or face ply.

Repair Limitation Guidelines. The maximum limit of repairs is determined by comparing the repair cost (labor and material) to the cost of a new like item under prevailing price conditions. This repair cost should not exceed 65 percent of the current cost of a new radome. NOTE: This maximum repair limit may be waived if like serviceable items are in a critical supply status.

Except for accomplishing Class I repairs, the manufacturer's drawings and/or detail specifications for the radome to be repaired must be available before repairs are made. Whenever a repair is made in the window area of the radome, it must be electrically tested unless stated differently in the specific -3 TO.

Radomes repaired in the field that meet one or more of the following conditions, do not require electrical testing.

a. If the repaired area is not within the designated window area.

b. If the repaired radome is designed for use at frequencies below 5000 megacycles per second.

c. If the repair is limited to a Class I repair and less than three miles (0.003 of an inch) thickness of resin has been applied. Note: For Type I, General Purpose Microwave Radomes, ONLY the following conditions apply.

d. When repairs affect only the outside skin layer (outermost ply), there is no limit to the size of repair that can be made.

e. When the repair does not affect the core or the band ply (innermost ply next to the core) or when the repair is outside the window area, and the total square area of the repair does not exceed 70 percent of the square area of the aperture of the applicable radar system antenna.

f. When repair requires replacement of core material, electrical testing is not required if the total area of the replaced core does not exceed one percent of the square area of the applicable radar system antenna aperture.

Personnel Qualifications. All individuals at field level activities are considered qualified to make repairs on fiberglass parts provided they have successfully completed the appropriate Tech School course relating to that type of fiberglass radomes. There are certain types of fiberglass radomes for which there is currently no repair course provided by ATC. Until such courses can be instituted, an individual is considered qualified to make repairs on these other types of fiberglass radomes after receiving on-the-job training from an experienced supervisor, and then satisfying the supervisor that the trainee can make repairs without direct supervision. It is the responsibility of the supervisor from that point on to maintain a close surveillance of all repairs made to insure that personnel under his direction continue to make good repairs once direct observation of the supervisor is no longer considered necessary. Personnel should be recertified annually.

Exercises (829):

If a given statement is in agreement with acceptable guidelines, place the word "yes" in the space provided. If a given statement is not in agreement, place "no" in the space and correct it to be acceptable.

____ 1. Repairs accomplished should restore the electrical and strength properties originally incorporated in the fabrication of the radome.

____ 2. In order to eliminate dangerous stress concentrations, small patches should be rectangular in shape.

____ 3. The difference between the repair cost and the cost of new item, determines if a radome should be repaired.

____ 4. For all repairs, the manufacturer's drawing and/or detail specifications for the radome to be repaired must be available before repairs are made.

____ 5. Electrical test of a repaired radome is not required if the total area of the replaced facing does not exceed one percent of the square area of the applicable radar system antenna aperture.

____ 6. Tech School training qualifies personnel to repair all types of fiberglass radomes.

830. Specify procedures, fitting methods or general requirements for given repair situations involving replacement of radome facing and core materials.

The repair of any radome requires the use of approved materials for repairing the damaged portion. Duplication of original materials, or authorized substitutes, as specified on the latest drawing and/or specification of the plastic part, is recommended in all instances.

Facing Replacement Factors. The facings of radome sandwiches are made of layers of glass cloth impregnated and bonded together with polyester or epoxy resin. In all repairs it is important to examine the direction of the threads in the original facings so that the direction of the threads in the replacement layers can be made to match in each ply. Be sure the glass cloth used in repair of radomes is that specified in Specification MIL-C-9084C with the same gage as the original ply.

Core Replacement Factors. In radome sandwich structures, the principal controlling dimension is the molded core thickness, density, and call size shown on the applicable manufacturing drawings and/or specifications. Core direction of the replacement honeycomb should be in the same direction as that removed to maintain uniformity even though the applicable specifications may not specify core directional requirements, figure 2-15 illustrates core direction (ribbon direction). Replacement honeycomb core sections may be installed by two methods: "flush fitting" and "interlocking." The method to be used shall be the same as that employed in the original fabrication of the item.

Flush fit method. The "flush fit" method requires that the replacement core be dimensioned to fit snugly into the prepared cutout area. Gaps between replacement core and existing core shall be kept to a minimum and is discouraged; however, they are permissible provided end item requirements are met, and if they are less than 1/8 inch in width and do not exceed 6 inches in length.

Interlocking fit method. The "interlocking" method requires that the replacement core be dimensioned so

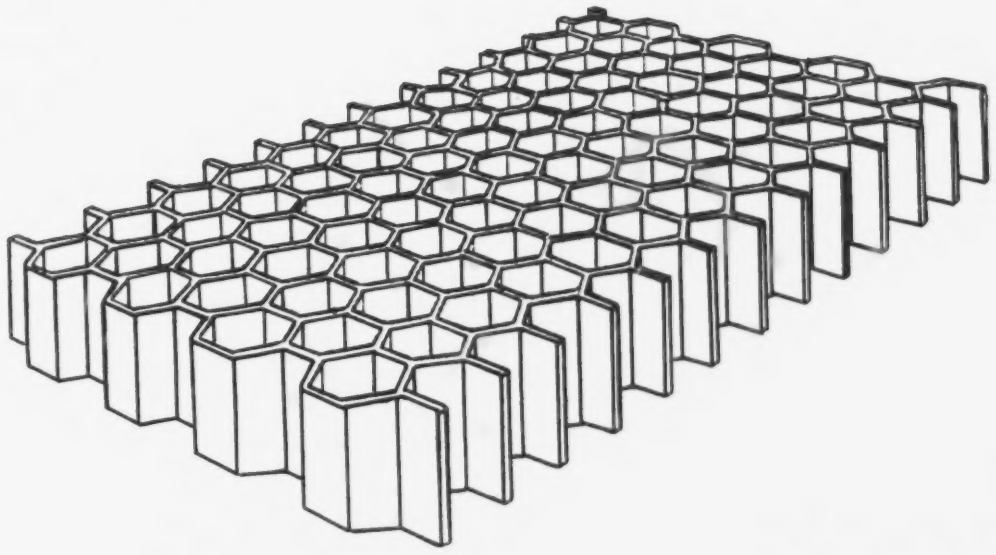

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Figure 2-15. Reference axes for honeycomb cores.

that the edges will overlap the existing core 1/2 to 1½ core cells. When the core is ready to be installed and correctly positioned, gently pound in place with a mallet or other appropriate tool. This operation cuts the corrugated ribbons of the honeycomb resulting in loose chips and fragments of the honeycomb material that must be removed from the core cells prior to laying up the bond ply.

Large pieces of replacement honeycomb or core that is to be installed where sharp curvatures are involved may require preforming to obtain proper fit and maintain desired contour. Preforming of honeycomb core shall be accomplished by positioning the replacement core on a matching area of a contour mold and then placing under 20 inches minimum vacuum pressure. Heat to 300° F.-320° F. for 30-40 minutes and cool to 125° F. or less before removing vacuum pressure. (Do not heat existing radome structure.) After the core has been performed, install in accordance with the instructions previously described.

Exercises (830):

1. When replacing facings on radomes, besides knowing the type of resin needed, what other fact must be determined before replacing the facing plies?
2. For a replacement section of core material to fit snugly in the prepared cutout area, what type of fitting method should you use?
3. When a replacement section of core material must be fitted to a curved surface, what procedures should you follow?
4. When it is necessary to overlap core material, what fitting method is used and what is the normal amount of overlap required?

831. From a list of statements about resins used when repairing radomes, identify the true statements and explain why the others are not correct.

Resin Selection Factors. Specifications for radomes allow a selection of approved resins normally of polyester type, Specification MIL-R-7575. Radomes fabricated from polyester type resins may be repaired with either Class 1 or Class 2 of any approved polyester resin unless the radome detail specification specifies the use of another class, Resin, Specification MIL-R-7575, Class 2, may be used as a substitute for

Class 1, but Class 1 is not a substitute for Class 2. These resins can be made to cure at different temperatures by adjusting the amount and type of catalyst. Since polymerization of the resin mixture is affected by ambient temperatures and humidity, resin mix formulations vary from one locality to another and may require adjustments from day to day or hour to hour for best working results. Use epoxy resins conforming to Specification MIL-R-9300 for repairs to radomes that used this type resin in the original fabrication of the radome. Basic resin mix formulations are described in the resin manufacturer's instruction sheet unless different from the radome manufacturer's process specification, in which case the later shall have precedence.

Safety Factors. In working with resins, catalysts, promoters and solvents such as acetone (necessary to clean equipment), local safety regulations pertaining to fire and health hazards must be complied with. Note: Only epoxies and sealers should be stored in a refrigerator. Resins, catalysts, and promoters are very reactive and should be stored in the original tight containers isolated from one another in a cool place (75° F. or less). Store solvents in approved safety cans or original tight shipping containers. Place the following warning on the refrigerator: WARNING: Do not store flammable resins, catalysts, promoters, or solvents in this refrigerator.

Exercises (831):
If a given statement is True or False, place the first letter of the word True or False in the space provided.

____ 1. Resin, Specification MIL-R-7575, Class 2, may be used as a substitute for Class 1 polyester resin.
____ 2. Resin, Specification MIL-R-7575, Class 1, may be used as a substitute for Class 2 polyester resin.
____ 3. Polymerization of a resin mixture is affected by ambient temperatures, humidity, and atmospheric pressure.
____ 4. Resin, Specification MIL-R-9300, may be used as a substitute for Resin Specification MIL-R-7575.
____ 5. Resins, catalysts and promoters should be stored in original tight containers.
____ 6. To store resins, catalysts, and promoters below room temperatures, separate areas are required.
____ 7. Under normal situations, only epoxy type resins should be stored in a refrigerator.

832. From information provided, select applicable work procedures to use when repairing fiberglass radomes involving the use of blankets, seals, and parting agents.

Blankets and Seals. Repairs to radomes are made by the hand lay-up method that requires application of uniformly distributed pressure to the lay-up to assure adequate bonding of the repair laminates. This pressure can best be applied by the vacuum bag process for concave surfaces and surfaces with complex curvatures. The procedures for applying the vacuum bag process were outlined during the discussion on laminated fiberglass repairs. Pressure for small repairs on convex surfaces may be applied by hand stretching a sheet of polyvinyl chloride (PVC) for polyvinyl alcohol (PVA) over the impregnated lay-up. This may be accomplished by cutting the PVC or PVA so that it will overlap the repair area approximately 2 inches. Tape a strip of tape along two opposite sides of the PVC or PVA over the repair and tape the opposite side while in the stretched condition. Exercise care during the stretching and taping operation to prevent displacement of the impregnated laminates. Tape the two remaining sides as required to maintain pressure on the repair area. Pressure may be applied to large simple contour layups by the use of a heated polyvinyl chloride blanket.

The pressure blanket process is more effective when used with layups that are impregnated with a resin formulation that will get at room temperature. Application of the heated PVC pressure blanket after the resin has gelled reduces the possibility of the impregnated glass cloth being displaced during the blanket installation process. Prepare this pressure blanket from a 0.020 inch thick PVC and cut it to conform to the area to be covered, so it can be clamped to suitable stretching bars. Construct the stretching bars so they can be clamped evenly to two sides of the blanket and provide a means of attaching to a rigid source to maintain the stretched condition. Tension springs between the rigid attach points and the clamping bars are suggested as a means of maintaining stable pressure. Pressure should be sufficient to maintain a minimum of seven psi over the pressure blanket surface. Heat the pressure blanket for 10 minutes at 260° F. prior to positioning on the wet impregnated lay-up. After the blanket is in position, "wipe out" excess resin and air bubbles in accordance with standard procedures, then cure in accordance with instructions for the resin formulation used.

Parting Agents. When it is necessary to use a mold to rebuild a portion of a plastic sandwich, treat the surface of the mold in some manner to prevent adhesion of the resin. If the mold surface is of double curvature, several coatings of one of the following parting compounds give good results: cellulose acetate lacquer, silicone grease DC4 manufactured by Dow-Corning Corporation. Other equivalent release agents may be used.

On the convex side of compound curvature molds, a polyvinyl alcohol (PVA) or vinylite parting film can often be stretched wrinkle free and on molds of single curvature cellophane works very well. Cellophane parting agent, Dupont, type 600PC, 600PT or equivalent, is recommended.

Exercises (832):

1. How can you reduce the possibility of resin impregnated lay-ups from shifting when using the pressure blanket process of applying pressure?

2. Describe the factors that are considered when fabricating pressure blankets.

3. How should the clamping bar used in a pressure blanket setup be constructed?

4. What must be done to a pressure blanket prior to being placed over the resin impregnated lay-ups?

5. How is the resin prevented from adhering to the mold when a mold is used to rebuild a portion of a plastic sandwich structures?

6. What should you do when a forming mold has a double curvature?

833. Given procedures required prior to starting a radome repair, state the methods or materials to use.

Remove radomes from aircraft prior to cleaning and preparing the part for major repair. Repair to erosion resistant coatings and Class I damage may be accomplished without removing the part from the aircraft provided (1) removal of the part is not practical and (2) precautions are taken to prevent the part from becoming contaminated during the repair process.

Cleaning Factors. Do not permit aircraft paint removers, stripping compounds, bright dip solutions or similar solvents to contact radomes and other fiberglass components. Some of these materials have been found to cause immediate and severe damage to radomes while other unauthorized solvents may cause a chemical reaction that will result in gradual deterioration and weakening of the structure. Mild detergent with water will be used for general cleaning of radome surfaces. When a solvent cleaner is required for removing oil and grease on radome surfaces, use a cloth dampened with methyl-ethyl-ketone, Specification TT-M-261B; naptha solvent, Specification MIL-N-15178, or toluol, Specification TT-T-548 (JAN-T-171, grade A optional). "Dampened means moist enough to allow liquid to be squeezed out and dry enough to allow liquid to be squeezed out and dry enough to prevent deposit of liquid during cleaning operation.

The area to be repaired and that area approximately 4 inches adjacent to damaged area must first be carefully wiped with a clean cloth saturated with methyl ethyl ketone or other approved cleaning agent. If paint has been applied to a radome, remove it by sanding or if equipment is available, by light seed blasting. Take extreme care during sanding operation to avoid further damage to the plastic facings of the sandwich construction. If seed blasting is used, take caution not to abrade the surface excessively and be sure to remove all loose grit or other foreign matter.

Pre-Inspection Factors. Accomplish moisture detection and removal procedures on all radomes *prior* to accomplishing Class II and Class III repairs. Moisture and other contamination seriously affect the electrical properties of a radome, therefore, radomes must be clean and dry prior to electrical testing. Radomes may require repair other than to obvious physical damage because poor electrical quality cannot be detected by visual means. Radomes that have a history of poor electrical quality or show evidence of extensive field repair should be electrically tested prior to repair in an overhaul shop. The objective of the pretest is to determine the electrical condition of the radome prior to repair. Electrical test personnel will outline, with a grease pencil, the areas of a radome that do not pass electrical test. Replace the areas outlined, taking extreme care to pinpoint the failed areas as closely as possible. Markings placed on radomes by test personnel must not be removed until the repair operation is begun. Radomes to be pretested should be dry, clean, and with the erosion resistant coating is removed.

Exercises (833):

1. What should be used for general cleaning of radomes?

2. What should be used to remove grease and oil from radomes?

3. When repairing a radome, how much of the surrounding area should be cleaned?

4. How should areas of a radome that do not pass the electrical test be marked?

5. What method can be used to remove paint from radomes?

834. Given listings of the procedures used to accomplish Class I and Class II repairs to damaged radomes, arrange each in the correct sequence.

Class I Repair Techniques. Scars, scratches, surface abrasion or minor rain erosion not penetrating through the facing shall be repaired as follows:

a. Clean damaged area thoroughly and carefully using a clean cloth saturated with methyl ethyl ketone or other approved cleaning agent.

b. Lightly sand the damaged area, using No. 280 grit sandpaper, clean the sanded surface thoroughly using methyl ethyl ketone, Specification TT-M-261B. Remove moisture and solvents completely to prevent their inhibiting the cure of the resin.

c. Apply one or two coats (depending on severity of the abrasion) of appropriate catalyzed resin to the abraded surfaces.

d. Over this coated surface, apply a sheet of colored cellophane or polyvinyl alcohol film extending two or three inches beyond the surface. The cellophane or PVA presents exposure to the air and provides a smooth surface against which the resin may cure.

e. Tape cellophane or PVA in place and work out all air bubbles and excessive resin with the hand or a rubber squeegee. Subject the resin coated surfaces to curing temperatures as specified by the resin manufacturer's instruction sheet.

f. After the resin has cured or set, remove cellophane from the cured resin and remove any excessive resin by sanding.

g. If rain erosion coating was removed or adversely affected by accomplishing the repair, replace it.

Class II Repair Techniques. Damages extending through two plies of the plastic facing or completely through one facing of the radome and possibly into one or more cores will require removal of that portion of damaged facings and cores and replacement by approved materials in such a manner that normal stress can be carried over the area. The preferred method of removing damaged face plies in accomplishing a Class II repair is by the stepped joint method. For small damages use the scarf method of repair.

For damage to one facing and core, use the step joint repair for the facing, with one exception: allow a minimum of one-half inch between the edge of the innermost ply and the periphery of the core material that is to be removed (see fig. 2-16). After thoroughly cleaning the repair area with MEK, cut a piece of core material to the exact size of the damaged area. The thickness and cell size must be to the manufacturer's specifications, as given in the applicable aircraft technical order.

When cutting of the honeycomb is required, a band saw is the most convenient equipment to use. The blade should have about 32 teeth per inch and a speed of about 5000 feet per minute. Slight variations in the blades or speeds may be necessary for particular cell sizes and densities. The optimum cutting conditions can probably best be achieved by trial and error for the specific application. After the area is thoroughly clean and dry, apply one coat of catalyzed resin to the cutout (honeycomb) area on the enclosure facing and a like amount on all mating surfaces of the replacement core. Then insert the core material with core cells that run in the same direction as the existing core. Make sure that the replacement core conforms closely to the existing undamaged honeycomb core. Insert the first impregnated ply over the core material. Place PVA film over the ply and apply light uniform pressure by means of tape, sand, or vacuum bags. Keep excess resin from entering the core cells, as this excess could hinder radar efficiency. Cure the repair by heat lamps or by inserting the entire part in an air circulating oven at temperatures in accordance with the resin manufacturer's instructions. Complete the repair (same as for laminate enclosures) as instructed by the applicable technical order.

Punctures of the skin where less than one cell size area is involved can be repaired by making a thick paste of resin mix and milled glass fibers. Work the resin mix with glass fibers into the puncture. Take extreme care to prevent excess resin from being injected into the core cells. When excess resin enters the cells, remove with a hypodermic syringe and needle. Vacuum bag the repair. Sweep out excess resin and entrapped air. Cure repair according to instructions contained in the applicable aircraft technical order.

Small separations or delaminations (sizes determined by repair restrictions in the applicable aircraft technical order) can be repaired by injecting (using hypodermic syringe and needle) a small amount of resin into the damage area. Apply pressure with C-clamps or vacuum bag, and cure according to the instructions contained in the applicable aircraft technical order. Repair is the same as that used for laminated skin delamination.

Exercises (834):

Arrange the following work procedures used for a Class I and Class II radome repairs in their proper sequence.

1. Class I

   a. Apply PVA film over the repair area.

   b. Sand the damaged area using No. 280 grit sandpaper.

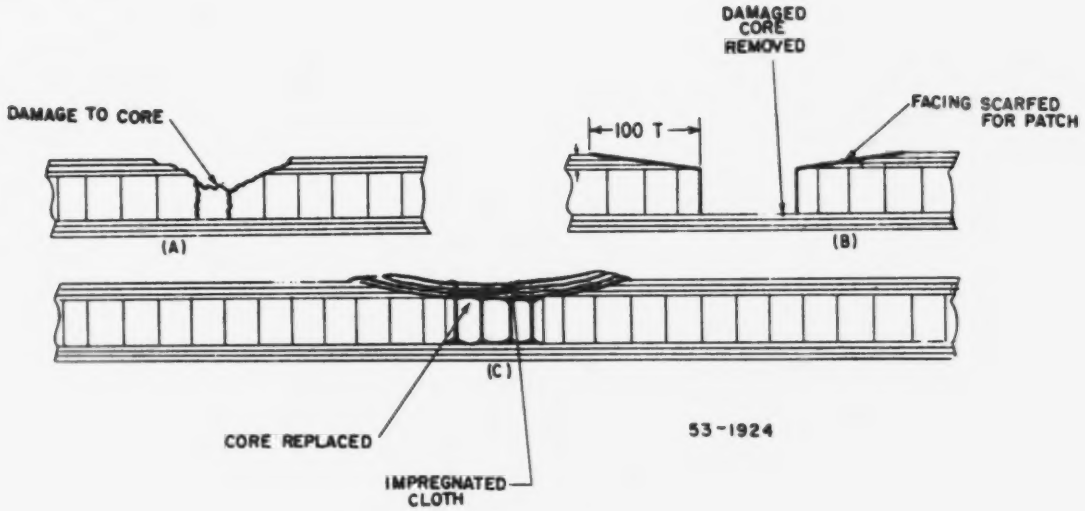

Figure 2-16. Class II fiberglass repair technique.

c. Apply one or two coats of resin.

d. Clean damaged area thoroughly using MEK.

e. Replace erosion coating.

f. Sand away excessive resin.

g. Remove PVA film from the repair area.

h. Cure the repair area.

2. Class II
   a. Cut replacement core material and replace plies for damaged area.

   b. Place PVA film over the ply and apply pressure.

   c. Clean damaged area with MEK.

   d. Insert first impregnated ply.

   e. Apply resin to cutout area and mating surface of the replacement core material and glass cloth plies.

   f. Remove damaged plies.

   g. Cure repair.

   h. Insert core material.

   i. Remove PVA film and complete replacement ply lay-up.

835. Specify procedures used to accomplish Class III repairs to fiberglass radomes.

Facing and Core Removal. A Class III repair is made to fiberglass radomes when both facings and

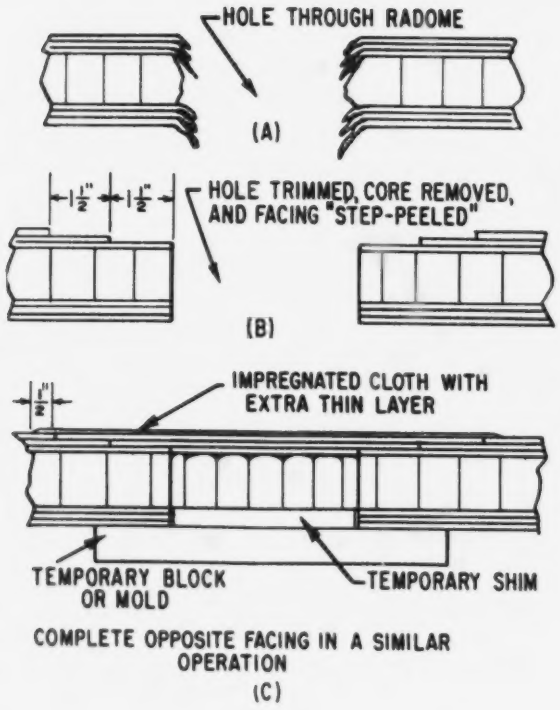

Figure 2-17. Class III fiberglass repair technique.

core material have been damaged. (See fig. 2-17.) The repair is made by removing and replacing the damaged face plies and core material as previously outlined for Class II repair. Never remove inner and outer fiberglass enclosure face plies at the same time. One facing must be completed before a repair is made on the opposite facing.

To accomplish a Class III repair, you must provide the opposite side of the sandwich material with a temporary mold or block to hold the core in place during the first face ply buildup. You can use a shim simulating the thickness of the opposite side facing and secure it in place by means of clamping, propping, or lashing.

Lay-Up Procedures. After molds or shims have been temporarily secured in place, the damage area is ready for rebuilding. The replacement core is coated with catalyzed resin on all sides (edges) and the top surface, leaving the bottom surface (next to the shim) uncoated. Insert the core in place on the repair. The glass fabric sheets (patches) are now ready to be impregnated with resin, cut to correct size, and placed in the repair, the smallest patch being laid over the replaced core. Complete the repair as you did for Class II repair.

Opposite Side Repair. Remove the mold or shim and repeat the removal and replacement of facing. There is one exception: make the cutout ply area approximately 2 inches larger than the first ply cutout area on the opposite face repair. This prevents the joints of the inner and outer repair area from being in the same position. Cure the repair according to the manufacturer's instructions for the resin used. Retain the contour of the enclosure throughout the repair. Never sand radomes to obtain the desired contour or to remove wrinkles. Finish the completed repairs as instructed by the applicable aircraft technical order.

Exercises (835):

1. How is temporary support for the opposite side of radome sandwich material provided?

2. Describe the procedures used to coat the replacement core material with resin.

3. What procedure is used to prevent the inner and outer joints of a repair area from being in the same position?

836. Designate testing considerations, procedures and materials that should be used to detect and remove moisture and oil from radomes.

General Data. Moisture and oil contamination of radomes is the cause of very serious degradation of the performance of aircraft radar systems. When moisture becomes trapped in radome cores, a prohibitive loss in radar efficiency occurs. Contamination also results in weakening of the radome facing and the facing to core bonding strength. Detection and removal of moisture and oil contamination as prescribed herein will be accomplished on all radomes prior to repair and/or identifying as serviceable.

Use a radome moisture indicator, ID-712, formerly known as a model AF-K2D moisture register to detect moisture. EXCEPTION: The small amount of moisture contained in filament-wound and other solid laminate radomes cannot be detected with the ID-712 moisture meter.

Equipment Set-Up. To determine the degree of moisture contamination, the radome moisture indicator should be used as follows:

a. Zeroing the Moisture Indicator. The case has a switch button to the right of the handle and a "zero adjustment" knob to the left of the handle. Hold the electrode "gun" at least 6 inches away from any object and press the switch button. The indicator pointer should swing to the right and stop at zero position.

Make necessary alignment corrections by turning the "zero adjustment" knob as required to zero the pointer.

b. Cleaning. The eight electrode contact buttons must be kept clean. Clean the contacts with dry cloth, fine abrasive paper, or an alcohol type solvent. Clean the contact surfaces of the calibration standard block in the same manner prior to checking calibration and calibrating the indicator. Dirty contacts on the standard or on the electrode will cause erratic readings.

c. Adjusting. The meter pointer should rest exactly over the red line (at 50 to the left of the dial) when the power is off. This adjustment can be made by turning the screw at the base of the needle pointer on the face of the dial.

d. Calibration. To calibrate the moisture indicator, lay the instrument case on a flat surface, press the "on" switch, and allow a few seconds for the circuit to warmup. After the warmup period, set the pointer at zero on the numerical scale and firmly press electrode gun contacts against corresponding cutouts on the calibration standard block attached to the instrument case. Any of the possible positions will produce satisfactory results. If pointer does not deflect to a reading of 20 ± 1/2, adjust the trimmer potentiometer located inside the instrument case about one inch below the metal disc marked "Trimmer Adjustment" until the correct calibration reading is obtained. The instrument shall be checked on the standard at least once a week or prior to use if used less frequently and at any time erroneous readings are suspected.

Testing Procedure. Remove all surface moisture prior to performing moisture test. Press electrode contacts firmly against radome surface. Take readings over the entire radome surface at 6 inch intervals. Do not take such readings within 3 inches of metal edges and microwave absorbing material or when surface temperature of radome exceeds 100° F.

Radomes with or without erosion resistant and antistatic coatings, must have a moisture content reading less than 15. Antistatic coated radomes must be tested from the inside surface. Radomes in excess of 3/4 inch thick and radomes that are double sandwich constructed (two layers of core separated by layers of fiberglass) shall be tested on both outside and inside surfaces to assure complete moisture detection.

Drying Procedures. Radomes that are moisture contaminated in excess of established limits should be dried in an air circulating oven at a temperature between 150° F. and 170° F. The drying time will vary depending on the amount of moisture (within the radome structure) and the condition of radome skins. Removal of damaged areas of the radome prior to starting the drying operation will allow the heat direct access to predominately wet areas; this will further allow more moisture to escape during the drying process. Subject radomes to oven temperature only as long as necessary to remove the moisture. A radome is considered dry if the moisture content reading registered on the moisture indicator is five or less. In order to remove moisture contamination that cannot be removed by the preceding procedures, remove and replace the sandwich material to accomplish drying.

Removal Procedure. Remove oil and contaminates other than moisture by replacing the entire contaminated area. Replacement of face plies and core material must accord with repair procedures prescribed for Class II and/or Class III repairs. Slight discoloration of core due to oil is not cause for core replacement. Replace core material that is noticeably dark in color due to oil saturation during level repair.

Exercises (836):

1. What procedures are used when zeroing-in the moisture detector?

2. What materials are used to clean the electrode contact bottoms on the moisture detector?

3. How often should the moisture detector be checked for proper calibration?

4. What factors must be considered when testing a radome for moisture using a moisture detector?

5. How can moisture be removed from a radome without accomplishing a repair?

6. When testing a radome for moisture, what reading would indicate a dry radome?

837. Indicate whether given statements correctly reflect acceptable working practices related to the solid laminated edge portion of radomes, and correct the invalid statements.

Repairing Predrilled Attachment Holes. Occasionally the drilled attachment holes (around the edges or in solid laminate portion of a radome) require plugging. The holes can be repaired as follows:

a. Sand the hole thoroughly to roughen the surfaces. Clean thoroughly using MEK or other approved cleaners.

b. Use fiberglass strands, 1/8 to 1/4 inch in length, and mix with catalyzed resin. Form a paste or putty-like mixture.

c. Press the mixture into hole and cover with cellophane or a parting film. Work all air pockets

(bubbles). Cure at temperatures recommended by the resin manufacturer.

d. After curing, remove parting film. To remove excess resin and obtain smooth surface, wet sand the area. Consult the technical order for instructions and appropriate resin. Remember, this repair is for previously drilled holes. Other damages will be repaired in accordance with the applicable technical order.

Sealing Requirements. Some edge bands on radomes require sealing because of porous edge laminates. Water also enters through rivets, bolt-holes, and hardware that must be sealed with a sealing compound. All radomes do not have to be sealed, only when a water contamination problem exists. The requirements for edge band sealing is determined by the appropriate directorate of material management and directed by applicable work specifications.

When it is necessary to seal edge bands, follow instructions given in the applicable technical order for the specific aircraft. When the specific aircraft technical order is not available, follow the instructions in TO 1-1-24. Apply sealants to rivets, bolts, and hardware. Use the techniques and methods mentioned in earlier paragraphs. The following is a brief outline of procedures for sealing:

a. Clean the area and metal in accordance with standard cleaning procedures.

b. Mix sealants in accordance with the manufacturer's instructions.

c. Apply it with a suitable sealant gun or spatula.

d. Apply it to the thickness required by the aircraft technical order.

e. Repair damaged sealant by removing loose particles. Lightly notch the adjacent sealant to obtain a rough surface for better adhesion. Clean the reworked area and reseal in accordance with the technical order.

Exercises (837):

In the space provided in front of each statement, indicate whether the statement is a valid work procedure by placing the word "yes." If the statement is *not* valid, place the word "no" and correct the statement.

____ 1. When repairing predrilled holes in the laminated edge portion of radomes, 1/8 to 1/4 inch strands of fiberglass cloth are used with the resin.

____ 2. After the laminated edge band or radomes has been sanded during fitting operations, the sanded area should be repaired as a Class II damage.

____ 3. When specific aircraft TO's are not available for radome sealing instructions, follow the instruction in TO 1-1A-12.

____ 4. To insure better adhesion when repairing damaged sealant, lightly notch the adjacent sealant.

____ 5. Wet sanding is done on repairs accomplished on predrilled holes on the laminated edge band on radomes.

Metal Bonded Honeycomb Structures

BECAUSE OF ITS close resemblance to a cross section of the comb that bees construct for the storage of honey, the structural sandwich type material you are about to study has been given the name "honeycomb." Let's define structural sandwich construction as "three or more laminations (layers) of different materials that act as one unit when they are bonded (glued) together." The honeycomb structure is manufactured from such materials as aluminum foil, glass fabric, stainless steel, or titanium formed in the shape of hexigonal cells. The finished product (honeycomb core between upper and lower facings) has more strength per pound than any other type of fabricated material presently known.

In this chapter you will study the characteristics of this type construction, detection of damage, material, tools, equipment, and the methods used in repairing metal bonded honeycomb. In addition you will learn how to inspect completed repairs and the safety precautions to take during inspection.

Repairs made to bonded honeycomb differ from repairs made on older aircraft in the methods, limitations, and materials used. Do not be alarmed at the seeming similarities between the material discussed in this chapter and our previous explanation of radome sandwich construction and repair. A comparison of the information will help you learn the specific skills needed in the repair of metal bonded honeycomb structures and parts.

3-1. Honeycomb Assemblies

Metal bonded honeycomb construction design is governed by the intended use of the panel or structure and is found in a variety of shapes and sizes. These aircraft components may consist of a whole section or a series of panels combined into an assembly. Metal bonded honeycomb is used as flat or curved panels in bulkheads, control surfaces, fuselage panels, wing panels, empennage skins, etc.

838. Specify characteristics of the materials and the design features of metal bonded honeycomb structures.

Construction Features. Metal bonded honeycomb (sandwich construction) consists of a core bonded between two metal facings by means of an adhesive or resin (see fig. 3-1). The honeycomb core is bonded to and between the two facings to produce a panel that is highly resistant to bending and yet is elastically stable to withstand high stresses. This type of construction has a superior strength-to-weight ratio over the metal structures used on older type aircraft. It can withstand sonic high frequency vibrations caused by the exhaust of jet engines used on modern aircraft. Bonded honeycomb construction costs less than old fastening methods, as fewer installation parts are required. Sealing problems are reduced by the use of honeycomb and the finished product is more aerodynamically smooth.

Special types of metal bonded honeycomb construction may be made of stainless steel, titanium, magnesium, wood, resin impregnated paper, glass, nylon, or cotton cloth in various combination.

Core materials. The honeycomb core material normally used is aluminum foil. The aluminum foil is formed in the shape of cells similar to a bee's honeycomb, in hexagon sizes of 1/8, 3/16, 1/4, and 3/8 of an inch in diameter, ranging from .0005 to .005 in thickness. The honeycomb core materials are stood on

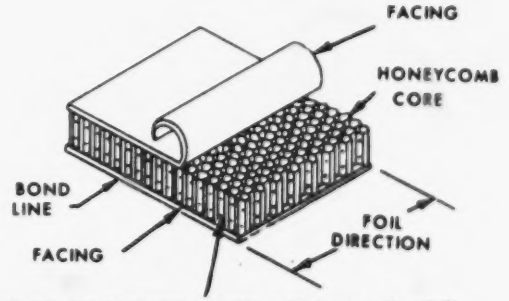

Figure 3-1. Honeycomb construction features.

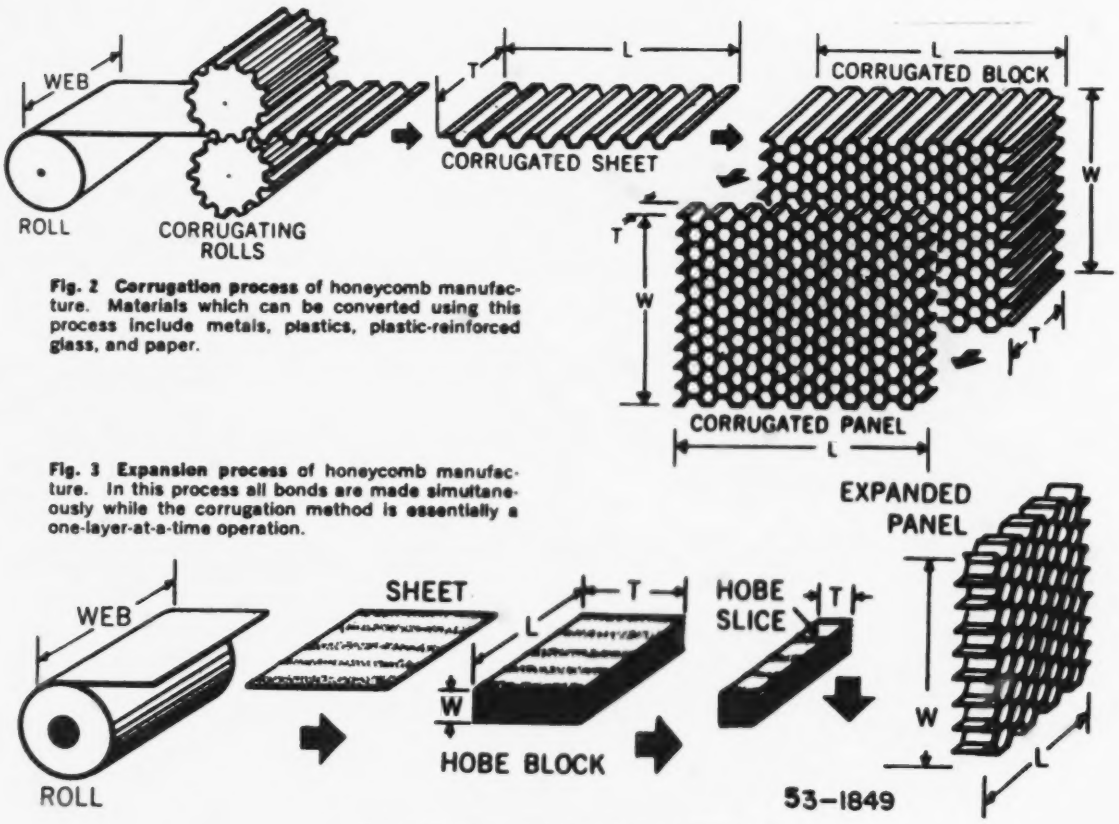

Fig. 2 Corrugation process of honeycomb manufacture. Materials which can be converted using this process include metals, plastics, plastic-reinforced glass, and paper.

Fig. 3 Expansion process of honeycomb manufacture. In this process all bonds are made simultaneously while the corrugation method is essentially a one-layer-at-a-time operation.

Figure 3-2. Honeycomb manufacturing processes.

end, separating and stabilizing the facings. This stabilizing effect gives the facings the rigidity and strength that is usually found only in much heavier solid structures. Figure 3-2, shows the different manufacturing processes used in making core material.

Facing material. A metal bonded honeycomb assembly has two facings — an inner and outer. The facings are the load carrying portion of a metal bonded honeycomb structure. Facing material may be fabricated from aluminum, stainless steels, titanium, and types of alloy steel. The aluminum facing material is usually fabricated from 2024-T3 or 7075-T6 aluminum alloys ranging in thickness from .008 to .040 or thicker.

Design Features. To meet certain design criteria in specific areas of an aircraft, metal bonded honeycomb parts are constructed in various configurations. Figure 3-3 shows the three main surface designs, the flat surface, the tapered surface, and the combination flat and tapered surface. When repairs are required, the type of surface design being repaired, will directly influence the repair procedures you will use.

Typical bonded honeycomb panels are divided, for repair purposes, into three individual areas. The flat section is referred to as the bay area. The area between the flat section of the panel (either rounded or tapered in shape) and the panel attachment area is called the "transition area." The transition area is also referred to as the panel edge closure area in some technical manuals. The panel attachment area is known as the flange area. Figure 3-4 depicts each of the individual areas earlier described. Technical order instruction will usually use the individual area call-outs when outlining specific repair procedures.

Exercises (838):

1. What type of material is usually used as core material for metal bonded honeycomb assemblies?

2. Which part of a metal bonded honeycomb panel is the load carrying member?

3. What are the three main surface configurations of metal bonded honeycomb assemblies?

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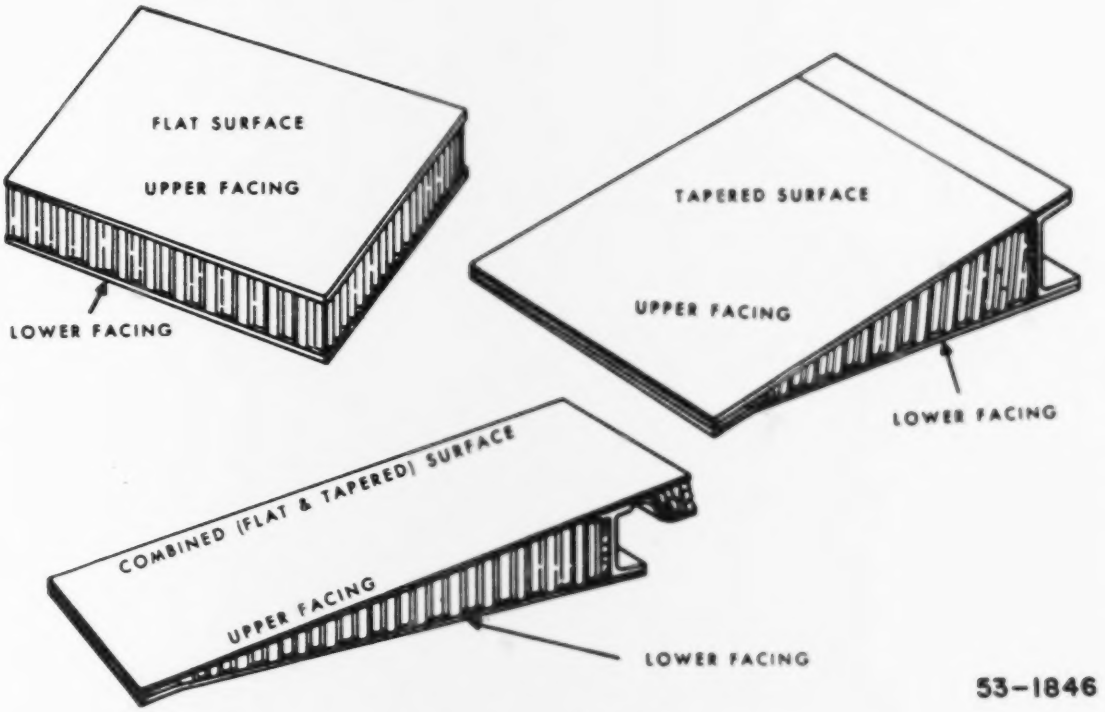


Figure 3-3. Honeycomb design features.

4. What is meant by the bay portion of a honeycomb panel.

5. Which area of a honeycomb panel is called the "transition" area?

839. Given descriptions of damages found on a metal bonded honeycomb panel, classify each type of damage.

Along with an increased use of honeycomb construction in modern aircraft, a certain amount of damage to this type of structure is sure to occur, but such damage may be reduced by improved maintenance and handling procedures. Most damage to honeycomb assemblies is caused by flight loads, ground handling, and sonic vibrations.

Presently there are no standard guidelines used by all manufacturers in classifying damages to metal bonded honeycomb structures. The number of damage classifications used varies from one TO to another. Some classifications are very specific, while others are general in nature. With this in mind, the classifications in this section have been developed primary to show you the different stages of classification. In actual work situations, always consult the -3 TO of the aircraft being repaired.

Class I Damage. Class I damages are dents, nicks, and scratches to the skin where the damage does not completely penetrate the skin or cause skin delamination. (Delamination is a separation of the core and face along the bond line—the thin line of adhesive between the core and face that holds the two together.)

Class II Damage. Class II damages include delaminations and cracks in the skin facings, without damage to the core materials. Included also are damages such as holes, tears, and gouges.

Class III Damages. Class III damages exist when one skin facing is penetrated and all or part of the core material is damaged.

The existence of water in a panel is normally considered to be a Class III damage because the water filled area is a delaminated area. The reason water filled areas are considered delaminated areas is because, with time, water will chemically combine with many adhesives, causing them to lose a large percentage of their adhesive properties.

Class IV Damages. Class IV damage is that penetrating both skin and the core materials.

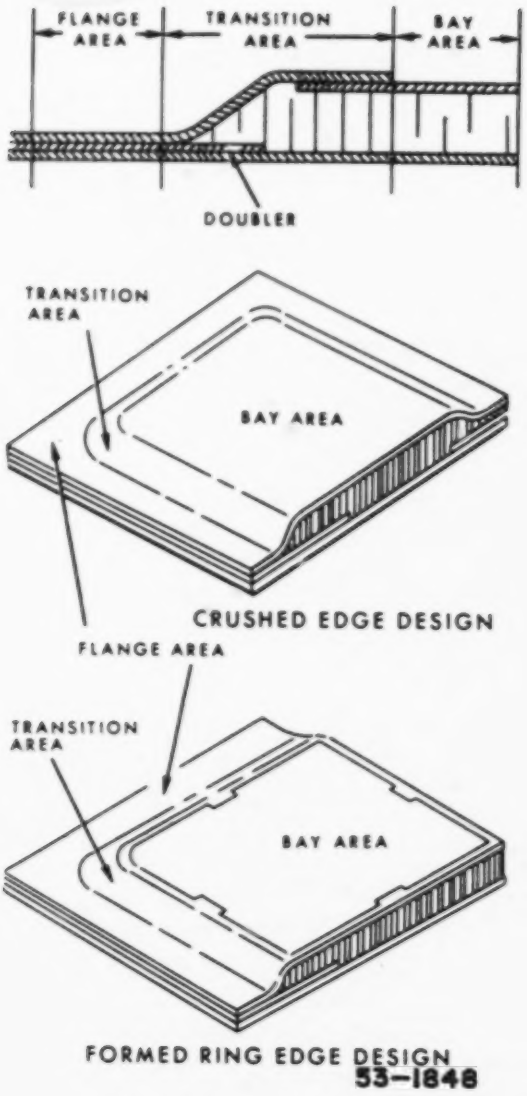


Figure 3-4. Honeycomb panel sections.

Exercises (839):
At the end of each statement, write in the classification of the metal bonded honeycomb damage described in the statement.

1. Skin separated from core material along bond line.

2. Scratches on inner skin facing.

3. Skin facing is penetrated, no core damage is present.

4. Water detected in trailing edge of honeycomb pane.

5. Skin facing is penetrated and core is completely crushed.

6. Both skin facing have been penetrated.

840. Specify the description, requirements or capabilities of bonded honeycomb structure inspection using the tap, spur wheel, visual, and chemical methods.

Inspection for damage is more critical for metal bonded honeycomb assemblies than for conventional structures, because honeycomb structure can have extensive hidden damage that is not easily seen during routine visual checks. Structural parts must be carefully inspected for areas that have poor bonding between facings and core. Areas having no bond are usually readily detectable by several of the common inspection methods, but areas having weak bond strength are exceedingly difficult to locate by visible inspection or non-destructive test methods.

Tapping Method. Tapping is one of the less difficult and effective methods for testing for voids or delaminations in the adhesive bond between the facings and the core of a sandwich part. This method is also called the metallic ring test. The only equipment necessary for this test is a small metal piece such as a coin (25¢ piece) or a light (1-ounce) aluminum hammer that can be manufactured locally. During inspection by the tapping method, parts should be freely supported on three padded points to eliminate sound interference from supports. A well-bonded area produces a clear tone, and a poorly bonded area produces a lower tone or a dull thud.

The tapping method is satsifactory for detecting delaminations, where the facings are not firmly attached to the core. If the delaminated facing and core are still in close contact, it is difficult to detect any difference between the "tapping tone" produced by these areas and by the well-bonded area. Poorly bonded areas cannot always be identified from well-bonded areas by means of tapping, but light tapping will usually give better indications than heavy blows. Considerable experience is required to locate defective areas, as parts of different construction give off different tones. The tones on the same part will also vary,

depending on the position you check; for example, variation in tone is especially noticeable within a few inches of the edge.

When using the tapping method, clean the panel by wiping the surface with a clean cheesecloth moistened with cleaning solvent. If you use a tap hammer, inspect the head for burrs, nicks, indentations, etc., that could damage the panel surface. Use a fine grit cloth to remove blemishes from the hammer head. Mark the panel to be inspected in approximately one square foot grids to assure complete coverage of the panel during inspection. In a smaller area, reduce the grid sizes as necessary. Grid lines should be marked with a grease pencil or an ink pencil. Do not use lead pencils because they may scratch the protective clad surface of aluminum panels, possible causing corrosion to form in the scratched areas.

Spur Wheel Method. An instrument used in place of the tapping hammer is the "spur wheel". When testing with the spur wheel, run it at a constant speed across the sandwich part and listen for a change in tone. Make certain the teeth on the wheel are equally spaced, or the wheel itself will produce a difference in tone.

Visual Method. Occasionally the delaminated skin will "oil can" away from the core, making visual or thumb pressure detection possible. Punctures, dents, scratches, cracks, and such may be inspected by conventional methods. Scratches should be given special attention because a scratch on the thin metal used in metal bonded honeycomb may become a crack.

Chemical Method. A caustic soda solution can be used for locating deep scratches on aluminum surface panels. If the area turns black after an application, the solution has penetrated through a scratch in the clad surface. NOTE: The Non-Destructive Inspection Specialist should be called when additional inspections are required.

Exercises (840):

1. Characteristically, under what condition does the tapping method of inspecting honeycomb panel give best results?

2. What sound is produced when tapping a delaminated area of a honeycomb panel?

3. Specify why grid lines should be used when inspecting honeycomb panels using the tapping method of detection.

4. Describe how the spur wheel method of detecting defective area of a honeycomb panels operates.

5. What type of defective area is usually detected by using thumb pressure?

6. What is indicated by a caustic soda solution test?

3-2. Metal Bonded Honeycomb Repair Equipment Tools

Effective repairs to metal bonded honeycomb assemblies depend largely on your knowledge, skill, proper use and maintenance of the repair tools and equipment. The design and high quality of workmanship built into these tools and equipment make them unique in the repair of bonded honeycomb assemblies. It is essential that you know and practice the techniques and procedures set up for each tool or piece of equipment to avoid personal injury and additional damage to the part being repaired.

841. Differentiate between sound and unacceptable working practices and correct given unacceptable practices.

Router Equipment. The tool primarily used to prepare a damaged honeycomb area for repair is a pneumatically powered, hand-operated router with speeds ranging from 10,000 to 20,000 rpm (revolutions per minute). It is used with a support assembly, bit, and template, as shown in figure 3-5. Router templates are used as guides when you are removing damaged honeycomb areas with a router. They may be designed and manufactured to fit the various sizes, shapes, or contours of the repair you are making. For larger holes, a template may be locally manufactured from aluminum alloy 0.125 inch in thickness; smaller holes may be cleaned without the use of a template. The multi-templates should be kept clean and lightly oiled to prevent rusting, and to maintain smooth operation during their use. A routing template can be used on a flat surface by applying double-backed tape to the edge of the template and centering it on the damaged area. Firmly press the template down on the double-backed tape to eliminate creeping or misalignment.

When using a routing template on a tapered surface, make a bridge of two manufactured wedge blocks at least 6 inches long and approximately the same degree

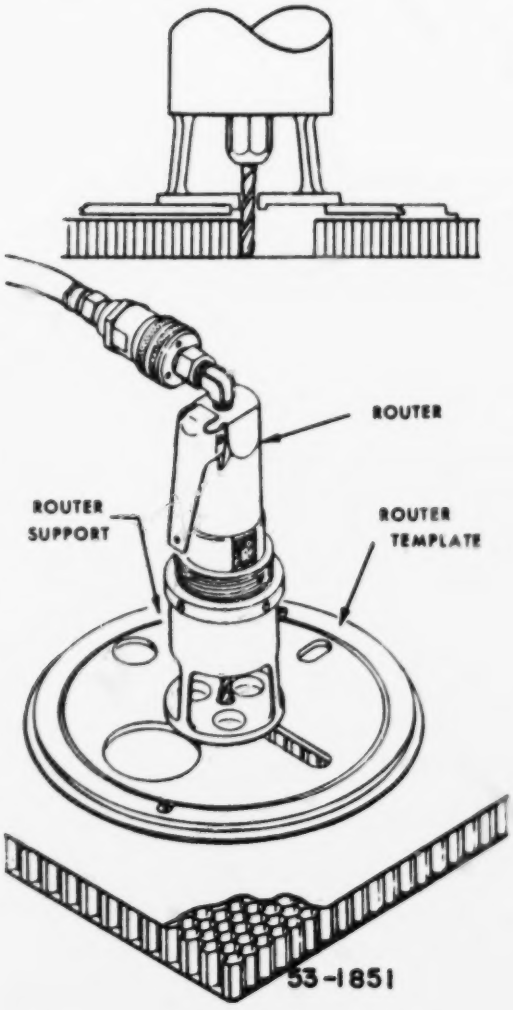


Figure 3-5. Router, support assembly and template.

of angle as that of the panel (see fig. 3-6). Apply double-backed tape to the top and bottom of the wedge blocks, which are placed on each side of the damaged area. Correctly position the template on the wedge blocks and press down firmly on the double-backed tape to prevent any creeping or misalignment.

When removing damage from bonded honeycomb, closely inspect the damaged area to determine how much should be removed. The router and template should be set up to insure the correct amount of damage that will be removed. Start the router at a 45° angle, gradually straighten it to a perpendicular position and move it in a clockwise direction to the outer limits of the template until all damage is removed. If more damage needs to be removed, repeat the entire operation. When aluminum core cells are damaged or tend to be closed during the routing operation, open them with tweezers or a penknife. Trim the core cells with a penknife to better shape the repair hole. When available, use a honeycomb cutter for trimming the rough edges of the core material. The honeycomb cutter is a beveledge socket chisel.

Pressure Jigs. Pressure jigs are used to apply pressure to repairs on under surfaces of honeycomb panels or assemblies in order to hold the repair materials and resins in place. The pressure is maintained on the repair area until the repair is cured. C-clamps, locally manufactured jigs, or vacuum fixtures may be used to apply the necessary pressure.

You must keep the surfaces around the repair area absolutely clean and free of any foreign materials in order to insure a good vacuum when using vacuum (suction) type equipment. An application of water or glycerin to the surface areas will aid on obtaining a good vacuum. Normal cleaning, care, and corrosion prevention keep the equipment in good working condition.

Scales. Accurate mixing of the adhesive ingredients by batches is considered one of the more important steps in the repair of bonded honeycomb structures. Information on the correct proportions of the epoxies, resins, and micro-balloons to be mixed into batches (both by weight and/or by volume) is given in the applicable section of the -3 technical order for the specific aircraft.

Scales generally used in the weighing of adhesive ingredients are of the balance type with an upright center, indicator, and weight sets graduated in grams. Although balance type scales are very sensitive, they are very simple to use. The scales may be used in

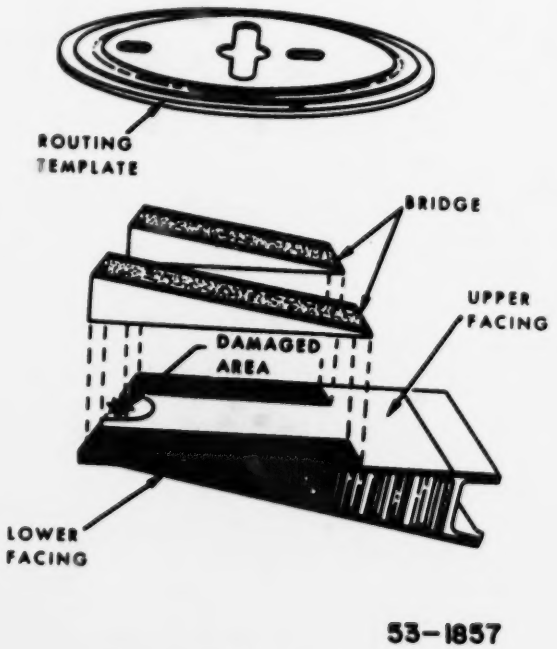


Figure 3-6. Wedge blocks and application.

weighing the adhesive ingredients by part or gram weight. In order to get accurate readings, the scales must be kept clean. Misuse of the scales or any accumulation of waste material will affect the scale's free movement and accuracy of its reading.

Explosive Meter. The explosive meter is an instrumented device that detects and indicates the amount of combustible gases. Before this instrument is used for the detection of combustible gases, turn it on and purge (clean out) any existing vapors lingering from the previous test by pumping the attached aspirator bulb. Then, extend the sampling tube to the area to be tested and pump the aspirator bulb again. The highest reading the indicator gives is the maximum explosive hazard in the tested area. If the explosive hazard is above the allowable limits, you should completely ventilate the area until a safe working condition exists.

The primary maintenance of instruments that use dry cells and filaments (such as the explosimeter) consists of replacing the parts as necessary. Calibration of the indicator must be performed by a qualified instrument specialist.

Exercises (841):

1. Determine if the following statements related to specific tools used when making honeycomb repairs are correct. If a statement is correct, place the word "Yes" in the space provided; if incorrect, place the word "No" in the space.

___ a. Before an explosive meter can be used, it must be checked for broken seals.

___ b. The primary tool used to remove damage from honeycomb panels is the router.

___ c. To correctly use the pneumatic router, a support assembly, bit, and template are needed.

___ d. When starting cutout using a router, it should be held 90° from the work surface.

___ e. Pressure jigs are used to apply pressure to the bottom surfaces of honeycomb panels.

___ f. Water is added to the surrounding surface of a repair, to aid in keeping heat temperatures within the proper heating range.

___ g. Scales may be used in weighing adhesive ingredients by part or gram weight.

___ h. Honeycomb cutters are used to remove rough edges of core material, after cutting.

2. Based on your answers to exercise 1, correct all statements that were incorrect.

842. Specify appropriate working techniques and conditions for using specially designed tools for cutting and shaping replacement core material for metal bonded honeycomb structures.

When replacement core material must be cut and shaped to fit a cutout area, specially designed tools should be used. These tools increase accuracy, save time and materials, and eliminate the hazards encountered when cutting and shaping core materials on conventional shop equipment.

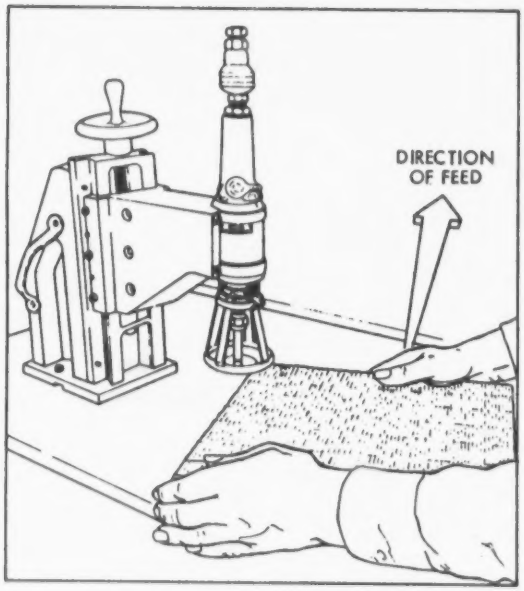
Core Slicer Assembly. The core slicer assembly, shown in figure 3-7, is used to slice and shape core materials for insertion into damaged areas of honeycomb panels. The core slicer assembly consists of a base, a vertical support, and an air driven motor mounted on a horizontal arm. The arm may be raised or lowered by use of a hand wheel and screw assembly that moves the arm in a dovetail in the vertical support. Different size diameter cutters are used with the core slicer assembly for slicing and shaping different size core materials.

A fixture assembly consisting of flat base and a hinged table assembly that can be tilted to 50° from the horizontal plane is sometimes used with the core slicer. The upper right hand illustration in figure 3-7, illustrates the fixture assembly. Wing nuts are provided in the supporting brackets to lock the table to a desired angle. Door pull handles are mounted on the ends of the rectangular base for manually positioning and guiding the fixture under the core slicer assembly when angular core material is being cut.

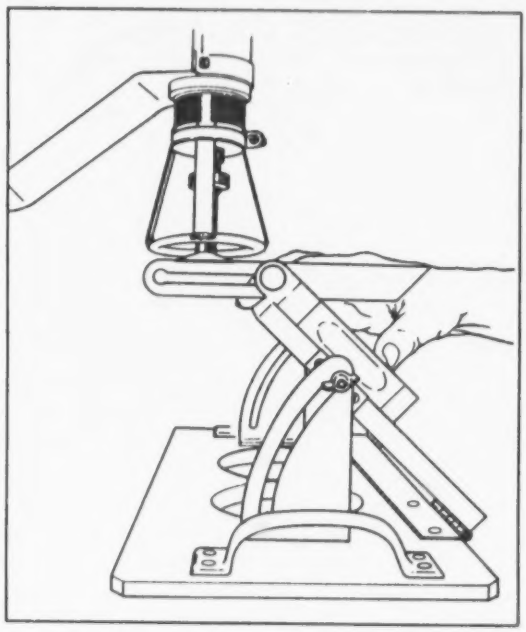
A spacer assembly can be bolted to the bottom of the core slicer assembly to provide additional space for slicing thick core material, or when angular cuts are to be made. The spacer assembly is a rectangular block containing a four-inch diameter hole.

Operation of the core slicer assembly is as follows:

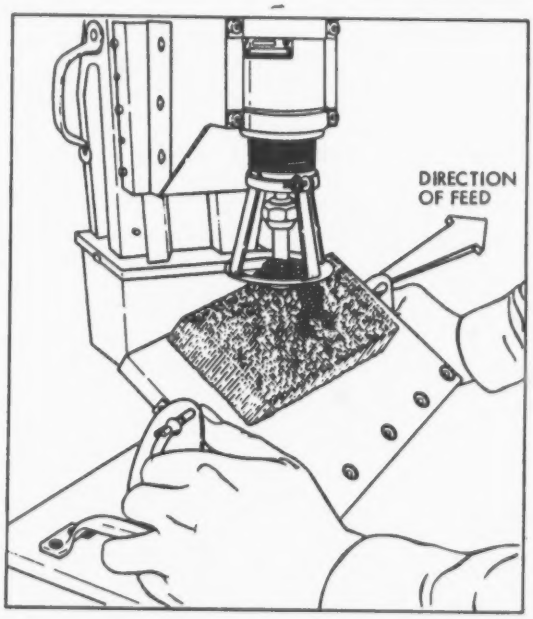
a. Place the core slicer assembly on the work table. Secure the core slicer assembly, using the four bolts and nuts.



SLICING PARALLEL CORE MATERIAL



SETTING THE ANGLE OF THE FIXTURE ASSEMBLY



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SLICING ANGULAR CORE MATERIAL

Figure 3-7. Core slicer assembly.

b. Remove the safety guard from the core slicer assembly.

c. Install the applicable size core slicer cutter in the chuck of the core slicer spindle. Tighten the collet securely, then install the safety guard.

d. Connect the core slicer assembly to the source of compressed air.

e. Obtain the required size core material and place the core material on the work table beneath the cutter.

f. Using the handwheel on the core slicer assembly, lower the cutter until it touches the top surface of the core material. Move the core material aside and lower the cutter an additional 1/4 inch. (WARNING: Always wear approved safety goggles or a plastic face mask, to protect the eyes from flying chips. Always wear cotton gloves to protect the hands from cuts. Always move the core material in the direction of feed as shown in figure 3-7.)

g. Operate the core slicer assembly and make a flat cut across the upper surface of the core material by sliding the material beneath the cutter.

h. Repeat steps (f) and (g) until the desired remaining thickness of core material has been obtained.

i. For making angular cuts on core material, apply a layer of double-back adhesive tape to the upper surface of the fixture assembly over an area sufficiently large enough to hold the material in place.

j. Measure the angle of the damaged core section using a bevel square, then adjust and lock the upper table of the fixture assembly to the corresponding angle.

k. Place the core material on the upper table of the fixture assembly.

l. Trim the upper surface of the core material by moving the fixture assembly beneath the cutter of the core slicer assembly. Do not cut more than 1/4 inch at any pass. Remove the equipment when the material is trimmed to the required shape and thickness.

Cylindrical Core Cutter. These cutters are used to cut straight core sections into 1, 2, or 3 inch diameter sections, depending on the size required to replace the damaged core material removal by the routing operation. A core 2 inches thick may be cut with each cutter. A common plastic-faced mallet is used to supply the impact force necessary to manually cut the core. Care must be exercised to position the cutter vertically above the core material so that a perpendicular cut is made. A knockout hole is provided in the upper face of each cutter to extract the core. Cutters may be resharpened by grinding the cutting edges to a 30° bevel. After resharpening, make sure the edge is free from burrs.

The cylindrical core cutter is used as follows:

a. Select the proper thickness of replacement core.

b. Place the core material on the work table with the core perpendicular.

c. Select the appropriate diameter cutter, then place the beveled edge of the cutter on the upper surface of the core material with the cutting edge parallel to the work table.

d. Tap the upper face of the cutter with a plastic-face hammer to drive the cutter downward through the core material. Hold the cutter perpendicular at all times. (See figure 3-8).

e. After the cutter has cut completely through the core material, eject the core from the cutter using a fiber rod 7/16 inch in diameter. Exercise care to avoid damage to the core.

Exercises (842):

1. When would it be necessary to use the spacer assembly when using a core slice assembly?

2. What is the proper adjustment of the cutter, when using the core slicer assembly?

3. When is it necessary to use double-back tape, when using the core slicer assembly?

4. How can you insure that a properly shaped cutout is made when using the cylindrical core cutter?

5. How is the core material removed from the cylindrical core cutter?

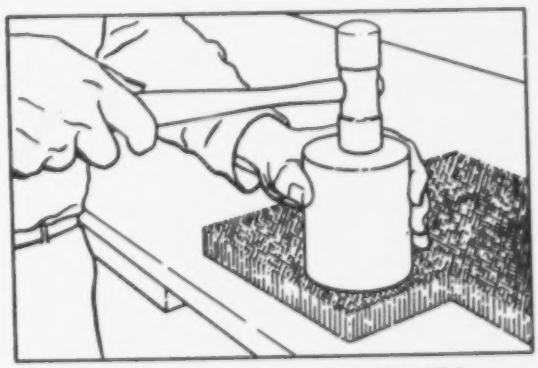

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Figure 3-8. Cylindrical core cutter.

837

843. Distinguish the types of equipment used to apply heat to a metal bonded honeycomb repair during the curing process.

Depending on where a repair is being accomplished, whether in the shop or on the flight line, different equipment can be used to heat a metal bonded honeycomb repair. Follow required safety precautions when using any of the following tools.

Infrared Heat Lamps. Infrared heat lamps are used to shorten the curing time of bonded honeycomb repairs from approximately 12 hours to 1 hour. A single-bulb lamp will adequately cure a repair up to 6 inches in diameter; but a large repair may require a battery of lamps to insure uniform curing of the repair area.

Center the lamps directly over the repair at a distance of about 30 inches. The setup is ideal to attain the recommended 130° F. curing temperature provided the surrounding areas are at room temperature (70° F.) Warmer or colder surrounding areas require that you adjust the heat lamps to the prevailing condition. You must exercise caution when working under arctic conditions, as a temperature differential of 150° or more will cause buckling of the surrounding skin surfaces, due to thermal expansion. As with any ordinary light bulb, the infrared bulb requires little or no maintenance; however, the support stands, wiring, and switches should be handled carefully and maintainted properly.

Heat Gun. The heat gun provides a source of electrically-heated air for curing sealants and adhesives. The heat gun operates on 115 Volt, 60-cycle electrical power, and is capable of delivering heated air at 35 CFM, at a velocity of 3000 FPM, and at a temperature range between 500° F. and 750° F. The heat gun is quipped with a three-position toggle switch, a replaceable heating element, a motor-driven fan, and a three-wire grounding cord and plug.

Heating Blankets. Thermostatically-controlled heating blankets are similar to the household heating pad, in that they are placed on a specific area to provide a source of heat. Heating blankets are available in a number of different sizes, with either a single or double filament leads. The heating blankets, which incorporate a single heating element and a single conductor, can be used in either a single blanket setup or a double blanket setup. Each single lead heating blanket contains a length of nichrome No. 31 AWG wire connected to a teflon-jacketed conductor and terminates in a connector. Each heating blanket is plainly stenciled *HOT SIDE*, in 1/2 of an inch letters, to indicate the side to be placed adjacent to the repair area.

A single-lead, single blanket setup is used when a small or medium sized repair area is to be cured on one side of a panel only. The double-lead, single blanket setup is used when a large repair area is to be cured on one side of a panel. The single-lead, double blanket setup is used when a repair is to be cured on both sides of a panel. Figure 3-9 shows the positioning of materials for a double blanket setup.

Regardless of the method used, the amount of heat being applied to a repair area must be closely controlled to insure proper bonding and to reduce the chances of damages resulting from over-heating a repair area. A pyrometer should be used whenever applying heat to a repair. A parting agent (teflon sheet 0.008 to 0.012 inch thick) must be placed between the heat blanket and the repair area. Heating blankets operate more economically and efficiently if they are blanketed with several layers of asbestos sheets. When a vacuum diaphragm is used as a pressure source, the asbestos sheets must be placed over the heating blanket and the vacuum diaphragm.

Exercises (843):
At the end of each statement, write in the type of heating equipment described in each statement.

1. Heating source is placed 30 inches from the repair area.

2. Operates between temperatures of 500° F. to 750° F.

3. Contains a length of Nichrome No. 31 AWG wire.

4. Surface temperature is not determined by distance from repair area.

5. Heating is accomplished by the application of hot air.

6. Asbestos sheets should be used.

7. Ideal heat temperature that should be developed using this heating source is 130° F.

8. Rate of heating can be regulated through the positioning of a toggle switch.

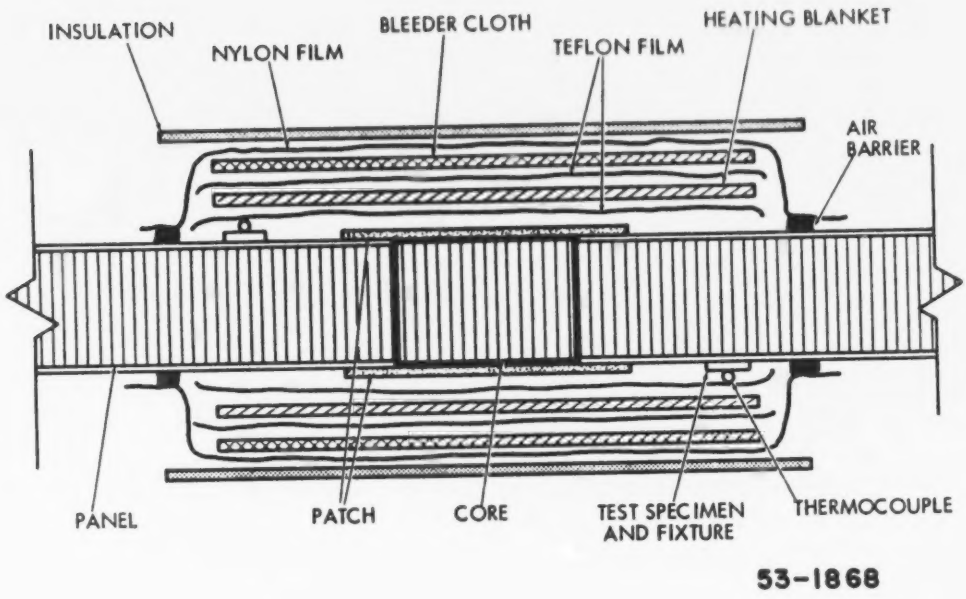


Figure 3-9. Double blanket set-up.

9. Rate of heating is thermostatically controlled.

10. A parting agent should be used when using this source of heat.

844. Describe hot bonding of aluminum and glass fabric repair parts to metal honeycomb panels in terms of temperature, heating rates, pressure settings and procedures.

The application of heat to aid in curing of a bonded repair is *not* a "hit or miss" affair. Strict adherence to working procedures, safety precautions, and temperature limitations is paramount, when heating bonded repairs. The following guidelines will help you obtain a properly hot bonded repair.

Hot Bond Curing Data. Hot bonded repairs require elevated curing temperatures in order to develop maximum strength in the repairs. For hot bonded repairs to gain required strength, the temperature and time must be observed throughout the cure to assure that they do not exceed the maximum or go below the minimum specified temperature for each type of repair. Repairs using glass cloth components and adhesives usually have a maximum curing temperature of 240° F. Repairs using metal (aluminum) components and tape adhesives usually cure at temperatures up to 350° F. Hot bonding procedures should be performed only when suitable hot bonding equipment, materials, and qualified personnel are available.

Aluminum hot bonding. The cure period for aluminum parts should be a minimum time of 45 minutes to a maximum of 6 hours at a temperature between 162.6° C. and 176.6° C. (325° F. and 350° F.). The rate of heating the repair area from the ambient temperature up to 162.6° C. (325° F.) should be as uniform as practicable and must not exceed 6.7° C. (12° F.) per minute nor be less than 1.1° C. (2° F.) per minute. Adhesive bonding requires that you securely retain the parts in position during the cure cycle. Pressure required during the curing of the adhesive may be supplied by any suitable device that will maintain and evenly distribute the required pressure throughout the curing cycle. Such pressure may be applied by any suitable method (for instance, direct clamping fixtures or by the use of a vacuum diaphragm). A minimum pressure of 10 psi must be applied to the assembly throughout the cure cycle. If direct clamping is used, exercise caution to prevent crushing the honeycomb core. At the completion of the cure period, cool the bonded repair as rapidly and evenly as practicable.

Glass fabric hot bonding. The minimum temperature at which the adhesive used with glass fabric normally cures is 71° C. ± 5° C. (160° F. ± 10° F.) for a period of 16 hours. A temperature of 93° C. ± 5° C. (200° F. ± 10° F.) requires a cure time of 90 minutes. The maximum temperature permitted is 116° C. ± 5° C. (240° F. ± 10° F.), which requires a cure time of only 30 minutes. A pressure of 5 to 10

psi must be maintained on the repair assembly during the curing period. This pressure should be applied by a vacuum diaphragm and vacuum equipment that will maintain and evenly distribute the required pressure throughout the cure period.

Exercises (844):

1. What is the maximum curing temperature that should be applied to glass cloth adhesives?

2. What is the maximum curing temperature that should be applied to tape adhesives?

3. What is accomplished by using elevated curing temperatures when making bonded repairs?

4. What is the maximum rate of heating that should be followed when bonding aluminum parts?

5. In order for the pressure being applied to a bonded repair to be effective, what should the pressure set up be able to do?

6. What is the minimum pressure requirement for bonding aluminum parts?

7. In order to cure a glass fabric adhesive in 30 minutes, what temperature is required?

3-3. Metal Bonded Honeycomb Repair Materials

The proper selection of repair materials for a specific metal bonded honeycomb repair should be made only after consulting the -3 technical order for a given aircraft. The importance of the correct materials for a specific repair cannot be overemphasized. Improper selection of materials definitely results in poor or unacceptable repair.

As you might already know or will realize as you get into repairing metal bonded honeycomb structures, there are numerous types of adhesives in use. The type you choose depends directly on the instructions given in the specific -3 TO. Adhesives come in various forms, such as paste, liquids, and films. The following are just a few of the ones in common use.

845. Cite specific characteristics and specifications related to paste adhesives used when making metal bonded honeycomb repairs.

General Data. A paste adhesive has a short work life and should be applied as soon as possible after mixing. Room temperature has a definite effect on the work life of the adhesive. As the temperature increases, the work life decreases. The ideal working or pot life temperature for this type of adhesive is 70° F. The curing of a paste adhesive is a chemical reaction. For each 18° F. increase in temperature, the rate of the chemical reaction doubles, or the work file is reduced by half. At lower temperatures, the adhesive has a tendency to thicken and become difficult to apply. A smooth, even coat, between 0.020 to 0.025 thick should be applied to repair parts with a fine bristled brush or spatula. After the repair parts are clamped in place, normally apply a low pressure (2 to 10 psi) until the adhesive cures. If the adhesive drags heavily on the brush and is difficult to work, cut off some of the bristles, which in effect stiffens the brush.

Specific Type. Adhesive EA9320 is a two-part (A+B), modified epoxy, solvent free, paste adhesive. The component parts must be weighed and mixed before use. Mix parts for approximately 5 minutes until the adhesive is an even blue color. Adhesive EA9320 has a work life of 30 to 40 minutes at room temperature of 75° F. to 80° F. The adhesive is suitable for injection with a sealant gun, and for trowel or brush application.

This adhesive will cure to optimum strength in 3 days at 80° F. to 90° F. When an accelerated cure is desired, maintain a minimum temperature of 160° F. for 1 hour. Maintain a vacuum of 10 psi throughout an accelerated cure cycle (for the first 16 hours when the adhesive is cured at room temperature).

Exercises (845):

1. Why is it necessary to quickly apply a paste adhesive?

2. What results when a decrease of temperature occurs when using a paste adhesive?

3. When applying a paste adhesive, what is the recommended thickness of the coating?

4. How can you tell when adhesive EA9320 is properly mixed?

5. How much of a temperature increase from the air-curing temperature is needed to cure adhesive EA9320 in one hour?

6. At a room temperature of 75° F. to 80° F., how long is the work life of adhesive EA9320?

846. Indicate whether or not statements given for adhesives used for metal to metal bonding when making bonded honeycomb repairs are correct.

Epon 933. Epon 933 is a two-component room temperature curing epoxy adhesive used for metal to metal bonding. Mixing of this adhesive should be done at room temperature in clean, wax-free containers. Epon 933 adhesive must not be thinned. If the adhesive becomes appreciably stiffer as it is being applied, this is an indication that the adhesive should be discarded.

Epon 933 adhesive will cure at room temperature in approximately 100 hours; however, curing time can be decreased by applying heat up to 93° C. (200° F.). A two-part surface conditioner, Epon 927, is used as a base for Epon 933. Epon 927 has a pot life of 4 hours when stored in an open container and 12 hours when stored in a closed container; it will cure in 2 hours at 76° C. to 88° C. (170° F. to 190° F.).

Epon 815. Epon 815, used with microballoons and curing agent T, is used as a metal to metal bonding adhesive because of its ambient temperature curing characteristics. This adhesive can be obtained in small flexible, plastic, "throw away" bottles. The "throw away" bottles contain the adhesive mixed with the microballoons and curing agent in a small flask. When using the "throw away" bottles, break the small curing agent flask by squeezing, then knead the curing agent into the adhesive until thoroughly mixed. The mixture must be used within 20 minutes after breaking the curing agent flask.

Conventional type mixing requires that the microballoons be added to the Epon 815 and stirred thoroughly until no lumps are visible for approximately 5 to 10 minutes. After they are mixed, add the curing agent (T) and stir until completely dispersed, approximately 3 to 5 minutes. Curing agent "U" can be substituted for curing agent "T". Also the adhesive can be used without the use of microballoons, if microballoons are not available. The cure time for the Epon 815 mixture will decrease as heat is applied. At room temperature, the cure time is 4 hours. With the increase of heating temperature up to 200° F. the cure time is reduced to 30 minutes. After the repairs have been coated with adhesive and clamped in place, apply a low pressure until the repair has cured.

Tape Adhesive HT-424. Metal to metal tape adhesive HT-424 is used to bind metal to metal or metal to aluminum core honeycomb. The tape adhesive is applied to only one of the two mating surfaces. Tape adhesive is applied to the bonding surface overlay skin patches doublers and core separators. Wear clean white cotton gloves at all times when handling tape adhesive. Do not use these gloves for any other purpose; change them frequently to insure cleanliness. Do not touch tape adhesives with bare hands. The tape adhesive is protected on each side by a separator sheet. Do not remove the separator sheet from either surface of the tape adhesive without immediate application of the tape to the component or bonding surface. Tape adhesive produces a uniform bond line and is quick and easy to apply.

Store tape adhesive in a freezer and allow it to come to room temperature before use. Use of cold tape adhesive tape may result in water condensation on the tape, and this will result in a poor bond. Tape adhesive cures at temperature up to 350° F.

Exercises (846):
Indicate whether a given statement is true or false by placing the letters "T" or "F" in the space provided.

__ 1. Epon 933 adhesive can be thinned using MEK.
__ 2. It takes over four days for Epon 933 adhesive to cure at room temperature.
__ 3. Epon 927 is used as a surface conditioner for Epon 815 adhesive.
__ 4. Epon 815 adhesive can be used with curing agent "U".
__ 5. To properly prepare a mixture of Epon 815 adhesive, it should be stirred at least 5 minutes.
__ 6. When heat is used to cure Epon 815 adhesive, the cure time and work life are the same.
__ 7. Tape adhesive should be mixed in wax-free containers.
__ 8. Tape adhesive must be used at room temperature.
__ 9. The same curing temperatures can be used for both Epon 815 and Epon 933.
__10. Tape adhesives are used with a surface conditioner Epon 927.

847. Match given characteristics of glass cloth adhesives (used when making metal bonded honeycomb repairs) with the specific adhesive type.

There are times and situations when glass cloth overlaps are used when repairing metal bonded honeycomb panels. When glass cloth overlays are required, a glass cloth adhesive, along with a surface primer, are used.

Glass Cloth Adhesives. A commonly used glass cloth adhesive is a mixture of equal parts of low viscosity liquid resins (Epon 812 and Epon 828) with equal mixture by weight of curing agents (Versamid 115 and Versamid 125). Mixing procedures for a batch mix is as follows: mix equal parts (by weight) of the Versamids, then mix the Epons and the Versamids together. A "batch mix" containing 20 grams (.04 lbs) yield the necessary quantity of adhesive to bond two 6 inch diameter layers of glass cloth. This mixture has a pot life of about 2 hours and will cure in 12 hours at room temperature (70° F.). When heat is applied (130° F.), the cure time is reduced to one hour. (See fig. 3-10).

Two types of hot bond glass cloth adhesives can also be used. One consists of Epon VIII, plus Epon 828 and curing agent RP-7; the other consists of Epon VIII and curing agent A. Both there adhesives have a pot life of approximately 2 hours at 75° F. However, at any time after the adhesives have been mixed, should it become too thick to apply easily, discard and prepare a new batch. Curing temperature and times for these glass cloth adhesives are:

TEMP F.°	*MINIMUM TIME*
a. 160 ± 10	16 Hrs
b. 200 ± 10	1½ Hrs
c. 240 ± 10	30 minutes

NOTE: Epon VIII and curing agent "A" can also be used to bond honeycomb plugs in place.

Surface Primers. When applying glass cloth overlays to metal bonded honeycomb panels, it is important that you use a surface primer. Magnesium surfaces are primed by adding primer base material (E42GP13) to an equal quantity of converter (V66KP11). This mixture is then sprayed or brushed on the surface to a dry film thickness of 0.0003 to 0.0005 of an inch. The primer must be dry for proper adhesion of the glass cloth overlays. Heat may be applied to speed up the drying if the coating has cured at 24° C. (57° F.) for 15 minutes and the heat source does not exceed 99° C. (200° F.).

For aluminum surfaces, an adhesive primer EC-776R is used. Apply with one inch varnish brush or cheesecloth to dry. Drying time is approximately 1 hour at temperature of 22° C. (75° F.), but it may be accelerated by application of heat, not to exceed 66° C. (150° F.). Apply the primer as rapidly as possible because it will become tacky in 10 to 15 seconds, thus pull and be ruined by any further brushing.

Exercises (847):
Match the characteristics given in column 1, with a specific glass adhesive mixture and surface primer given in column 2, by placing the letter/s of the adhesive mixture or surface primer in the space provided in column 1.

Column 1	*Column 2*
____ 1. Can be cured in 30 minutes.	a. Epon and Versamid mixture.
____ 2. Can be cured in 1 hour.	b. Epon 828, Epon VIII, RP-7.
____ 3. Used on magnesium surface.	c. Epon VIII, Curing Agent "A".
____ 4. Drys in 1 hour at 75° F.	d. EC-776R.
____ 5. Maximum curing temperature is 130°.	e. E42GP13/V66KP11.
____ 6. Mixture consist of equal parts of components.	
____ 7. May be used to bond honeycomb plugs in place.	
____ 8. Becomes tacky in 10 to 15 seconds.	
____ 9. Must air-dry some, before heat can be applied.	
____ 10. Used on aluminum surfaces.	

848. Differentiate between the types of adhesive used to bond core replacement materials in place when making a metal bonded honeycomb repair.

There are several adhesives developed especially for use when bonding replacement cores in honeycomb structures. Some require mixing a number of components, while others are tape design adhesives, while others are tape design adhesives that expand when heated.

Mixture Type Potting Compounds. A commonly used potting compound consists of a mixture of Epon 815 (low viscosity liquid resin) and curing agent "T", with microballoons added in required amount to control the viscosity (thickness) of the mixture. The added microballoons have no curing effect on the mixture. This compound has a bench or pot life of 15 to 20 minutes, and a cure time of approximately 4 hours at room temperature (70° F.). An alternate mixture consists of equal parts of Epons 812 and 815 and Versamids 115 and 125, to which microballoons are also added. This alternate compound has a pot life of 2 hours and a cure time of 12 hours at room temperature (70° F.), or 1 hour when heated. (See fig. 3-11). Epon 815, and curing agent "A" can be used as a potting compound when microballoons are added.

Corfil is another type of potting compound. Corfil potting compound is available in bulk quantities of

COMPONENTS	PARTS BY WEIGHT	PARTS BY VOLUME
EPON 812	100	83
EPON 828	100	83
VERSAMID 115	100	100
VERSAMID 125	100	100

NOTE: Mixture pot life is approximately 2 hours at 70° F (21° C). Cure time is approximately 12 hours at 70° F (21° C) or 1 hour at 130° F (54° C).

MIXING PROCEDURE

A "Batch Mix" containing 20 grams (.04 lbs) yields the necessary quantity of adhesive to bond two 6 inch diameter layers of glass cloth.

1. Add Epon 828 to Epon 812 and mix thoroughly
2. Add Versamid 115 to Versamid 125 and mix thoroughly
3. Add Epon mixture to Versamid mixture and mix thoroughly

NOTE

Epon 812 and Epon 828 with the correct amount of versamids and two six-inch fiberglas disks are available in separate compartments in a flexible plastic container, part no. 80055-78. Manufactured by Fenwal Laboratories Inc., Framingham, Massachusetts.

53–1870

Figure 3-10. Glass cloth adhesive data.

Corfil 615 paste and curing agent DRA packed in individual containers or bulk quantities. Components must be weighed and mixed prior to use. Corfil is also available in kits of pre-weighed components packed in plastic containers. The container serves as a mixing chamber and adapts to a sealant gun for easy application.

Mixing consists of adding 7 parts (by weight) of DTA curing agent to 100 parts (by weight) of Corfil 615 paste. Mix components for approximately 5 minutes to insure a proper mixture. Corfil 615 potting compound has a work life of 30 to 60 minutes at a room temperature of 70° F. to 90° F. Initial set will occur in 6 hours at 70° F. Optimum strength will develop in 24 hours at 70° F. or higher. When an accelerated cure is desired, maintain a constant temperature of 120° F. ± 10° F. for at least 1 hour.

Tape Design Potting Compounds. Special types of core replacement adhesives have been developed that require no mixing prior to use. Commonly referred to as form-in-place tape adhesive or core splice materials, they look very similar to the tape adhesive discussed for metal to metal bonding. Potting compound tape adhesives are available in various thicknesses from 0.020 to 0.100 of an inch thick, to allow for bonding of the different cell sizes found in honeycomb panels. For 1/4 of an inch cell size, a 0.100 thick foam adhesive tape is used. For 3/16 of an inch cell size, a 0.075 thick foam adhesive tape is used. A 1/8 of an inch cell size requires the use of a 0.050 thick adhesive tape. When splicing two different cell size cores together, the maximum thickness of the foam tape adhesive to use is that for the larger cell.

Foam tape adhesives come with protective facing sheets on both sides that are removed just prior to use. Foam tape adhesives must be stored in a freezer and, before being used, brought to room temperature. Prior use would result in water condensation on the core material and an improper bond. Also, it must be remembered that foam tape adhesives have limited expansion properties and, unless the joints are closely fitted, the gap between the core pieces will not adequately fill with the foam adhesive.

Foam tape adhesives offer a number of advantages over the mixture type potting compounds. Uniform bonding around the replacement core is assured plus, foam tape adhesive is easier to apply. Proper bonding results because of errors eliminated by not having any mixtures to prepare.

Exercises (848):
In the space provided at the front of each statement, indicate the type of adhesive which matches the specifications described in each statement.

1. Has a work life of 15 to 20 minutes.

2. Mixture is a ratio of 7 parts to 100 parts.

3. Optimum strength develops in 24 hours at room temperature.

4. Offers a uniform bond line around replacement core.

5. Honeycomb cell sizes directly influence selection factors.

PREFERRED POTTING COMPOUND

	COMPONENTS	PARTS BY WEIGHT	PARTS BY VOLUME
STIFF MIX	EPON 815	100	37
	MICRO-BALLOONS	30	100
	CURING AGENT "T"	22	10
AVERAGE MIX	EPON 815	100	37
	MICRO-BALLOONS	24	63
	CURING AGENT "T"	22	10
THIN MIX	EPON 815	100	37
	MICRO-BALLOONS	16	50
	CURING AGENT "T"	22	10

NOTE

Epon 815 with the correct amount of micro-ballons and curing agent "T" is available in separate compartments in a flexible plastic container, part Nos. 80055-44 and -45, manufactured by Fenwall Laboratories Inc., Framingham, Massachusetts. See figure 10-29.1 If the plastic containers are not available the proper mix may be obtained using the following mixing procedure.

MIXING PROCEDURE

1. Select the desired mix.

NOTE

The stiff mix is desirable when conducting overhead repairs or for core plug bonding.
The average mix or the thin mix is desirable when conducting upper surface repairs.

2. Add micro-balloons to the Epon 815 and mix for 3 to 5 minutes.

3. Add curing agent "T" to the EPON 815 micro-balloon mixture and mix for 3 to 5 minutes.

ALTERNATE POTTING COMPOUND

COMPONENTS	PARTS BY WEIGHT	PARTS BY VOLUME
EPON 812	100	83
EPON 828	100	83
VERSAMID 115	100	100
VERSAMID 125	100	100
MICRO-BALLOONS	80	880

MIXING PROCEDURE

1. Add Epon 828 to Epon 812 and mix thoroughly.
2. Add Versamid 115 to Versamid 125 and mix thoroughly.
3. Add Epon mixture to Versamid mixture and mix thoroughly.
4. Add micro-balloons to Epon-Versamid mixture and mix thoroughly.

NOTE

Epon 562 may be used in place of Epon 812 until existing stocks are depleted.

HOLE DIAMETER	GRAMS OF PREFERRED POTTING COMPOUND REQUIRED (APPROX)	GRAMS OF ALTERNATE POTTING COMPOUND REQUIRED (APPROX)
.50	3	5
.75	6.5	10
1.00	11	18

AMOUNT OF POTTING COMPOUND REQUIRED FOR ONE INCH DEEP HOLE

53-1869

Figure 3-11. Potting compound data.

6. Has a work life of 2 hours.

7. Available in pre-weighted containers.

8. Cures in 4 hours at room temperatures.

9. Requires no weighing of components.

10. Uses no microballoons when mixing components.

849. State selection considerations for determining the proper glass cloth and core material to use when making a metal bonded honeycomb repair.

Core Replacement Material. Damaged sections of aluminum cores in bonded honeycomb structures are normally replaced with nylon phenolic honeycomb core material. Where proper tools are available and specified by TO instructions, aluminum replacement core material is used. Both the nylon and aluminum core materials are available in various thickness and cell sizes and must be cut and shaped to fit the required repair configuration. When selecting replacement core material, usually the same cell size is selected as the original core cells. Certain TOs recommend the use of smaller size cells because of the increased bond area created by the smaller size cells. When selecting aluminum replacement core material, be sure the material is 5052H39T and that it is treated for corrosion.

The replacement core material should also be similar to the original core in that it is either perforated or nonperforated. The perforated honeycomb core material contains a series of pin holes through the walls of each cell. These pin holes permit gases and inner pressures developed during curing to be removed, prior to sealing the structure. The nonperforated type of core materials contain no pin holes, an important factor when it is necessary to remove moisture from a honeycomb panel. Perforated cells permit moisture to be removed from metal bonded honeycomb panels by using a vacuum set-up. NOTE: For core materials involving the use of titanium, stainless steel, etc., follow TO guidelines before attempting core replacement.

Glass Cloth Materials. When it is necessary to use glass cloth overlays, use glass cloth No. 181, having either a Volan-A or Garam RS-49 finish. Both of these finishes have good wet and dry strength properties. As for the number of glass cloth overlap required, this is determined by the thickness of the original metal facing material. Normally, the below listed guidelines are followed.

Original Facing Thickness	*Number of No. 181 Glass Cloth Overlays Required*
(a) .010 or less	(a) 2
(b) .012	(b) 3
(c) .016	(c) 4
.018	
.020	
(d) .022	(d) 5
.025	

NOTE: When an alternate type of glass cloth is used, such as No. 128, additional overlays are needed, because glass cloth No. 181 is 0.009 inch thick, while glass cloth No. 128 is only 0.007 thick.

Glass fabric cloth must be handled with care, stored properly, and be perfectly clean of any dirt, moisture, oil, or other contaminants that may cause imperfect adhesion of the materials with which it is impregnated. Snags and sharp folds in the cloth will cause its strands to break; the result is a local strength loss in the finished repair. Exposure to or contact with the glass fabric, dust, or particles may cause bodily itching or irritation.

Exercises (849):

1. When should you select aluminum core material when making a core replacement repair?

2. What is accomplished by using a smaller cell size for a replacement section of core material?

3. Why is it recommended that glass cloth overlay materials have either a Volon-A or Garan RS-49 finish?

4. If it was necessary to substitute glass cloth No. 128 for No. 181, why are additional overlays required?

3-4. Metal Bonded Honeycomb Repairs

Specific recommendations as to the type of repair and procedures to use when making a metal bonded repair, vary among the manufacturers of aircraft. What is considered a permanent repair on one aircraft, is often considered a temporary repair on another aircraft. So it is important that you always consult the specific -3 TO. The repairs used in this section are designed to illustrate to you the variety of repairing techniques that can be used.

850. Identify accurate statements related to the procedures used to insure quality of workmanship when making metal bonded honeycomb repairs.

Referring to early volumes, the repair principles such as restoring original strength, weight, contour, and corrosion resistance were continually stressed. These principles must also be foremost in your mind when making metal bonded honeycomb repairs. Due to the nature of the construction of honeycomb structures, the most effective repair is a bonded repair. So, it only follows that specific bonding guidelines must be closely followed when accomplishing metal bonded honeycomb repairs.

Bonding Guidelines. Each type of repair requires a different specific adhesive that governs the procedures and limitations of the repair. Select a bonding method that best repairs the part, and, the repair should be permanent, if possible. Generally, hot bond repairs are superior to cold bonded repairs of the same patch material. Bonded metal patch repairs, either hot or cold, are better than glass cloth patch repairs. However, surface contour may be such that glass cloth patches are more advantageous. Since hot bonded repair procedures require suitable heating equipment to effect the cure of adhesives, these repairs should be performed only where equipment and qualified personnel are available. If, due to lack of equipment or times, a part is repaired by the least desirable method, this repaired part must be closely observed for possible recurrence of damage until the next down time of the aircraft, at which time the part must be permanently repaired or replaced.

Repair Factors. A successful bonded repair depends largely on diligent cleaning of the repair area and parts, proper selection of method and size of repair, correct mixing of adhesives, and successful installation of the repair parts. Cure temperature must also be maintained to insure that the adhesive has been sufficiently cured before the repaired parts are put into service use.

No cleaning or repairing of damaged metal bonded honeycomb structures should be accomplished when the temperature of the repair area is below 4° C. (40° F.). If the damaged area is below 4° C. (40° F.), the damaged part must be warmed either by moving the aircraft to a warmer location, by enclosing and warming the repair region, or by removing the damaged part from the aircraft and performing the repair in a warm place.

When repairs to damages that slightly exceed allowable limits are delayed, the damage may propagate to a point where the panel is nonrepairable or require extensive repairs. With this in mind, whenever a repair is delayed or a temporary repair made, a record of the location and extent of the damages must be kept and the repair inspected at regular intervals. Repairs must be made immediately to any damaged area that increases in size. Replace temporary repairs at the earliest possible time.

Exercises (850):
Identify true or false statements by placing the letter "T" or "F" in the space provided at the beginning of each statement.

___1. Hot bonded repairs are superior to cold bonded repairs.
___2. Cold bonded metal repairs are preferred over heated glass cloth patches.
___3. When temporary repairs are accomplished, they should be replaced only when they show signs of increasing in size.
___4. Bonding repairs can be accomplished as long as the temperature of the repair area is 40° F. or higher.
___5. Glass cloth patches should be used when weight limitation are a critical factor.

851. Specify materials and procedures employed to meet required cleaning standards for making metal bonded honeycomb repairs.

Chemical cleanliness is extremely important in all bonded repairs because currently used adhesives will stick only to chemically clean surfaces. Effective surface and repair material cleaning is of primary importance to the success of any honeycomb repair. An area that is contaminated with grease, oil, wax oxides, etc., will not produce a good bond. The quality of the repair is largely determined by the quality of the cleaning that preceded it.

Surface Preparation. All finishes, adhesives, or corrosion must be removed from the repair area. If a repair area is to be heated to a high temperature for curing, the adhesive or corrosion must be removed from the repair area. If a repair area is to be heated to a

high temperature for curing, the adhesive, the lacquer finishes, and aluminum anti-rain-erosion finish must also be removed from the immediate area that will be heated.

Clean the repair area as follows:

a. Remove surface oils, greases, and other foreign matter from external surfaces by scrubbing the repair area with clean white lint-free cloths moistened with trichlorethylene, specification MIL=T=7003. Change cloths frequently. When surface is clean, wipe it dry. Do not allow solvent to evaporate to dryness.

b. Abrade repair area faying surface of the skin with aluminum wool until a bright surface is obtained. Remove abraded cuttings and clean area with cloths moistened with MEK. When surface is clean, wipe dry. Do not allow solvent to evaporate.

c. Clean the internal faying surface of the part to be repaired as thoroughly as possible with MEK.

To determine whether an area is completely and thoroughly clean, use a water "break" test. This test is a simple application of a thin film of distilled water to the cleaned area. Any "break" of the applied thin film of distilled water will indicate that the area has not been cleaned enough and that the process must be repeated. Observe safety precautions closely when you are working with cleaning solvents, especially when the work is overhead or in confined areas. For your personal protection wear rubber gloves, face shield, and a respirator.

To ensure good adhesive adhesion, it is essential that all aluminum surfaces to be bonded are alodized. Apply alodine to all exterior edges and faying surfaces of the repair area.

Repair Part Preparation. All aluminum repair components should be degreased and cleaned just prior to assembly of the repair. Clean skin patches with an organic solvent degreaser and acid etched. Clean the aluminum honeycomb plugs in a mild acid-detergent solution and rinse them in clean water and dry. Clean plastic honeycomb plugs by immersing and agitating them in MEK for 1 or 2 minutes, followed by air drying for 15 to 30 minutes. Wear clean white cotton gloves when you handle the cleaned parts. Do not touch the cleaned parts with your bare hands.

Exercises (851):

1. What cleaner is used to remove surface oil and grease prior to starting a bonded repair?

2. How should you apply the cleaner named in question 1, and what factor must you remember?

3. Why is it necessary to have aluminum wool listed among cleaning items used for making bonded repairs?

4. To insure good adhesion, what should you do to aluminum surfaces prior to applying the adhesive?

5. What should be done if a "break" occurs during a "water break" test? Why?

852. Designate mixing components (and ratio) and the procedures surface putty repair of dents in metal bonded honeycomb panels.

Minor dents in metal bonded honeycomb panels that are within damage limitations can be restored to surface contour requirements by filling the dented area with a surface putty. You should always consult the specific -3 TO before attempting the following repair. Refer to figure 3-12 during the following discussion.

General Information. This repair is designed to restore aerodynamic smoothness to honeycomb assemblies by filling minor dents with epoxy surface putties, such as Devcon F, Epibond 8550, or Eccobond aluminum. Most surfacing putties are a two-component, solvent resistant, aluminum filled epoxy, used primarily for hole and groove filling and for limited aerodynamic smoothing.

Surface Preparation. When metal surfaces are being repaired, remove all paint from the area. The metal surfaces must receive channel surface cleaning treatment before application of the epoxy putty. Also, the surface must be thoroughly clean and dry at the time of epoxy putty application. A mixture of one part MEK to one part of lacquer thinner can be used to clean the surface. This solution should be applied with clean cloths and immediately wiped dry with a clean cloth. The solution should not be allowed to air dry.

When plastic surfaces are being repaired, prepare the surface as follows:

a. Abrade surface carefully and thoroughly with 320 grit or finer abrasive sheet. All gloss shall be removed from area, and the surface should have a uniformly dull condition.

b. Wipe away residual dust with a clean cloth wet with MEK or lacquer thinner, and immediately wipe dry with a clean dry cloth. Allow additional air drying until there is no solvent odor.

Mixing Procedures. To facilitate mixing, the components of the surface putty should be stabilized at 60° F. to 90° F. Better mixing and working characteristics

CHECK LIST

PREPARATION

1 SECURE SPECIFIED TOOLS AND MATERIALS.
2 REMOVE PAINT.
3 SAND DAMAGED AREA.
4 CLEAN REPAIR AREA.
5 MIX SURFACING PUTTY.

REPAIRING

6 APPLY SURFACING PUTTY.
7 CURE SURFACING PUTTY AND SAND TO CONTOUR.

REFINISH

8 PRIME AND PAINT.

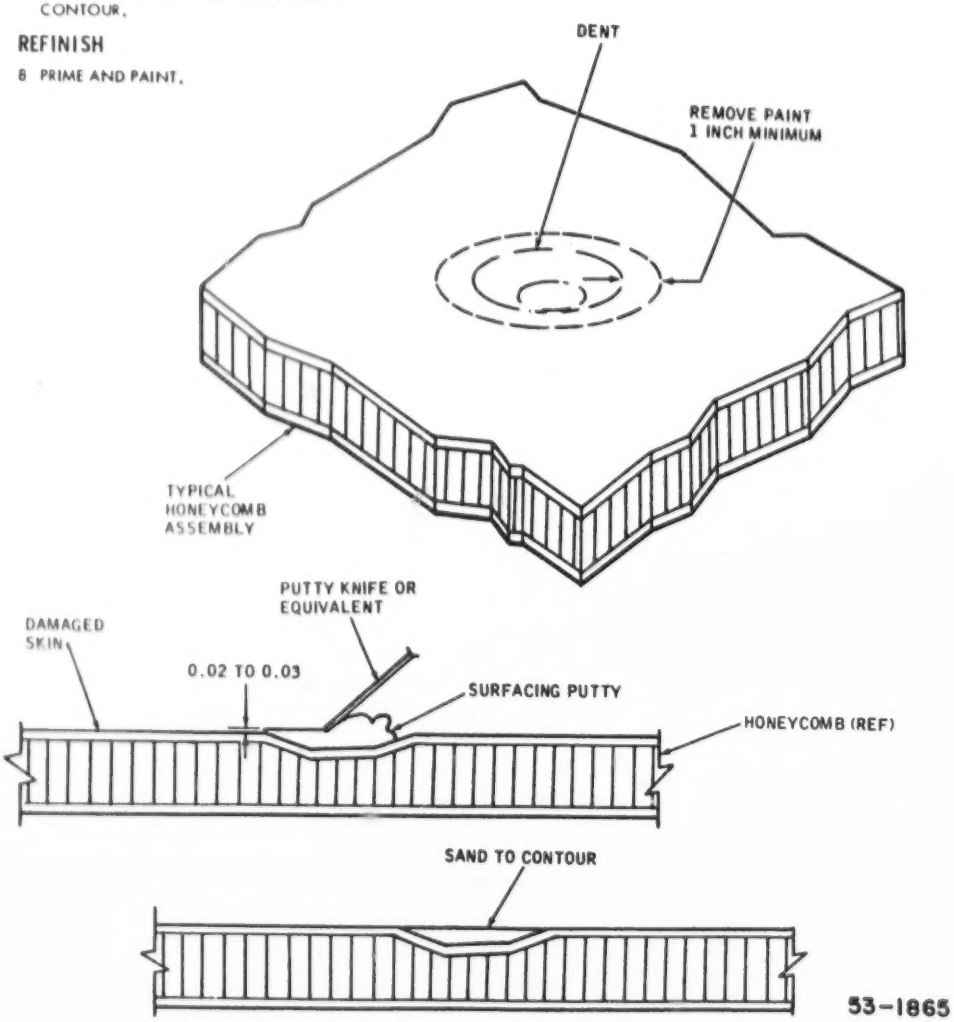


Figure 3-12. Dent repair procedures.

are obtained in the upper ranges of this temperature range. Do not intermix components of one manufacturer with those of another. Components should be thoroughly mixed on a clean hard surface to a uniform color. Also, use a putty knife or spatula to minimize air entrapment and soft spots in the cured putty. The ratio of components should be as specified in TO specifications. Normal working pot life is 15 or 25 minutes at 77° F.

Application Procedures. The putty should be worked into the dented area to approximately the desired finished contour. A final drawdown with a spatula or putty knife wet with MEK or lacquer thinner will help smooth the surface. Extra filling is not required, as shrinkage is normally less than 2 percent. Curing times will depend on the specific type of putty to be used. Usually the higher the temperature, the shorter the curing time. After the putty has cured, sand the repair area to the required contour using 280 to 320 grit abrasive sheets to remove ridges; then use a finer abrasive, such as 400 grit, to meet the overall smoothness requirements. Following the sanding, clean the repair area thoroughly, using a clean cloth dampened with MEK or lacquer thinner. The final step involves reapplying any surface treatment that has been removed or damaged by sanding.

Exercises (852):

1. What must you do to metal surfaces prior to applying a surface putty?

2. What are the components and the ratio of the mixture you use to prepare metal surfaces for surface dent filling?

3. What procedure is used to produce a uniformly dull condition on plastic surfaces prior to applying a surface filling putty?

4. What must be done to the components of a surface filling putty prior to mixing?

5. How can you eliminate air entrapment and soft spots in a surface putty mixture?

6. Once a surface putty has cured, what should you do to restore smoothness requirements?

7. To assist in the smoothing of a surface putty after application, what should you do?

853. Describe the techniques for repairing dents in metal bonded honeycomb panels using a dent puller assembly.

When dents on metal bonded honeycomb panels exceed damage limitations, they must be repaired. For large dents that have caused extensive core damage, the damaged area must be cutout so that the core and skin surface can be repaired. For smaller dents, with minor core damage, the following repair procedures can be used.

Dent Puller Assembly. For reforming the skin surface of minor dents, a dent puller assembly should be used to restore the dented area to its original contour. The dent puller assembly consists of a clear plastic base, a threaded mandril, and a retaining nut. The mandril, which is fabricated from threaded stock, and has a right angle hook on the lower end and wrenching flats on the upper end. Steps 1 and 2 of figure 3-13, show these features. The panel must be pre-drilled with one or more 7/32 (0.219) inch diameter holes (depending on the size of the dent), to accommodate the hook end of the mandril. The retaining nut is used to pull the mandril upward, by using a suitable size adjustable wrench (see step 3 of fig. 3-13).

A dent may be removed in one pull when it is no greater than one inch in diameter or in several pulls when it is larger. Since the puller base is clear plastic, you can easily see the condition of the skin surface after each pull is made.

Dent Removal Procedures. Before using the dent puller assembly, consult the applicable -3 TO for limitations of dent sizes. You should use the dent puller assembly in the following manner:

a. For dents one inch in diameter or less, drill one hole through the skin in the approximate center of the dent. For larger dents, drill two or more holes as required. Drill only through the dented skin. Do not allow the twist drill to penetrate the core to any extent.

b. Build up the undamaged skin around the dent, using two layers of masking tape as shown in step 1 of figure 3-13.

c. Back off the retaining nut on the dent puller assembly sufficiently to allow the hook end of the mandrel to be inserted into the drilled hole(s). Insert the mandrel as indicated in step 1 of figure 3-13.

d. Place the clear plastic base over the mandrel and install the retaining nut finger tight.

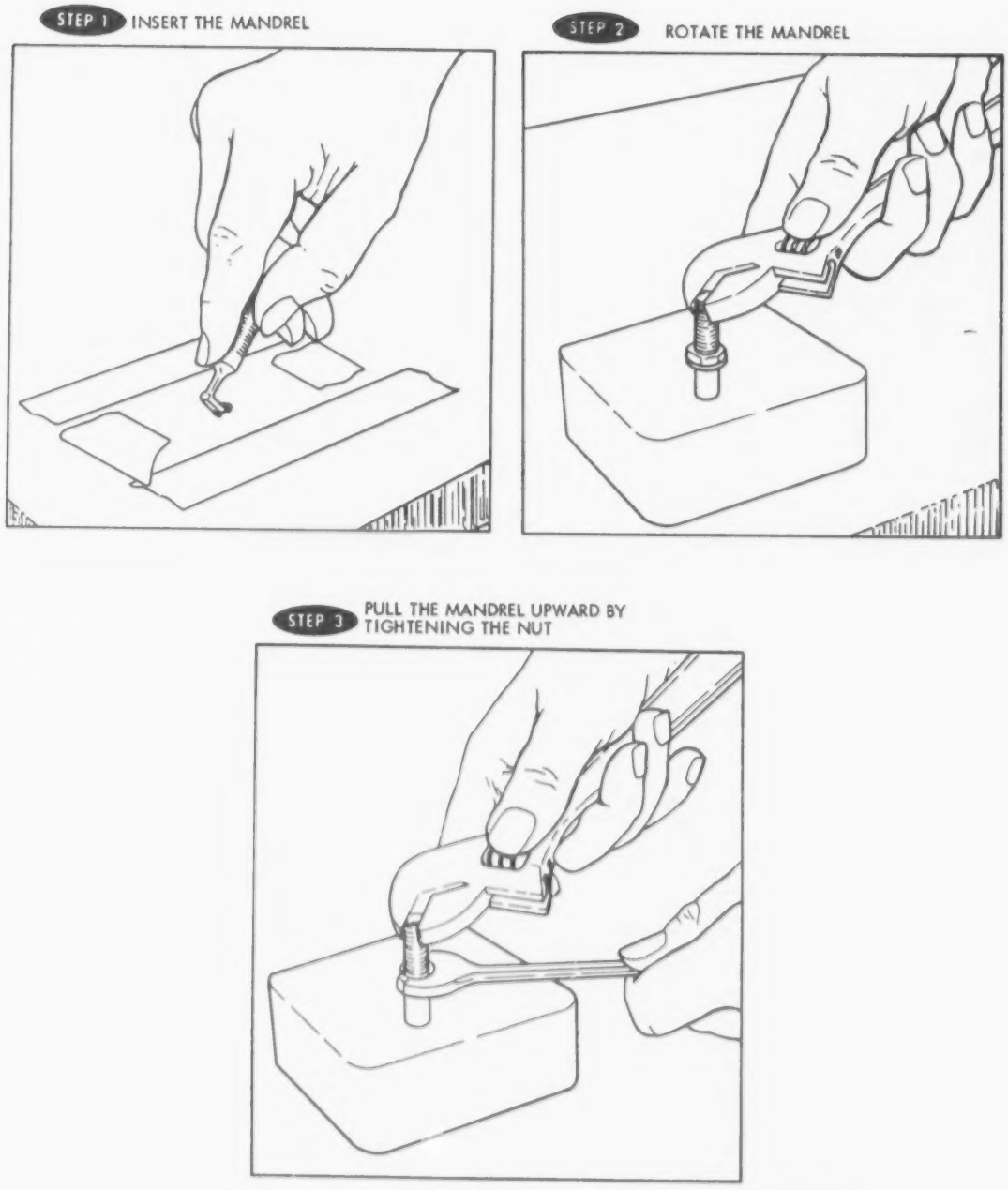


Figure 3-13. Dent pulling procedures.

e. Using a suitable size adjustable wrench, adjust the wrench to fit the milled flats on the upper end of the mandrel (Step 2 of fig. 3-13).

f. Using an open-end wrench to hold the retaining nut in place, rotate the mandrel counter-clockwise one complete turn to pull the skin upward. (Step 3 of fig. 3-13.)

g. Turn the retaining nut one-half turn clockwise as viewed from above.

h. Rotate the mandrel counter-clockwise one complete turn to raise the dented surface.

i. Repeat steps *g* and *h* until the dented skin is flush with the contour.

j. Repeat previous steps if more than one hole was drilled into the skin.

k. Remove the dent puller assembly and masking tape. Clean and patch the panel in accordance with procedures specified in the applicable TO.

Usually a potting compound is inserted into the drilled holes to fill the void created by the crushed core material. Once this is done, place a metal or glass cloth overlay over the area.

Exercises (853):

1. What factor determines the number of holes drilled when using a dent pulling assembly?

2. Why is there a hooked end on the threaded mandrel of a dent puller assembly?

3. How far, into the dented area, should the necessary hole/s be drilled?

4. After insertion of the mandrel into the drilled hole, what is the next step?

5. What action results when the retaining nut is turned clockwise on a dent puller assembly, once set-up?

6. After the dent area is straightened, what is the next step?

854. Given work procedures related to repairing minor cracks and delaminations in metal bonded honeycomb panels, state the reason for using a specific work procedure.

Skin delamination occurring in the bonded structures is the separation of the facing(s) from the honeycomb core structure and the splitting apart of the skins or facings. Skin cracks in these structures take on a new meaning; what appears to be just a small scratch or defect may in fact be an actual crack, especially on the thinner materials. The repair techniques, methods, and procedures given are to be used only as a guide. For specific repairs on a given type of aircraft, consult the applicable section of that -3 technical order.

Minor Skin Delamination Repair. Delaminations may be repaired by drilling a series of holes in the delaminated area and injecting a liquid adhesive into the void. The following procedure should be employed. Refer to figure 3-14, during the discussion.

a. If possible, tilt the damaged assembly to an inclined or vertical position. This will aid in the flowing of the adhesive when injected between the skin and core material.

b. Drill No. 40 holes through the skin at the top and at the bottom of the delaminated area. Holes should just penetrate the skin. You should use a drill stop to avoid damage to the honeycomb core.

c. Layout and drill additional holes between the first two existing holes. Holes must be spaced a maximum of 2 inches apart.

d. Deburr holes and remove all drill cuttings.

e. Mix adhesive and load sealant gun. The sealant gun must have a tip smaller than the No. 40 holes in the skin.

f. Insert the tip of the sealant gun in the lowest hole and inject adhesive into the void until adhesive flows from the next hole above. Do not apply pressure to the skin during the injection process. If pressure is applied to the skin, the void will close, making it impossible to inject adhesive for maximum bonding. Inject the adhesive slowly to allow air to rise above the adhesive. If necessary, the tip of the sealant gun can be heat-formed for angle delivery, if more convenient.

g. Seal bottom hole with tape and slowly inject adhesive into second hold until adhesive flows from third hole.

h. Repeat previous step (g) progressively from hole to hole until adhesive flows from the top hole.

i. Clean off excess adhesive at all holes.

j. Cure adhesive using heat and pressure.

k. Once the adhesive has cured, inspect the repair for effective bonding.

NOTE: Some TOs require the use of an outer overlay to prevent moisture penetration.

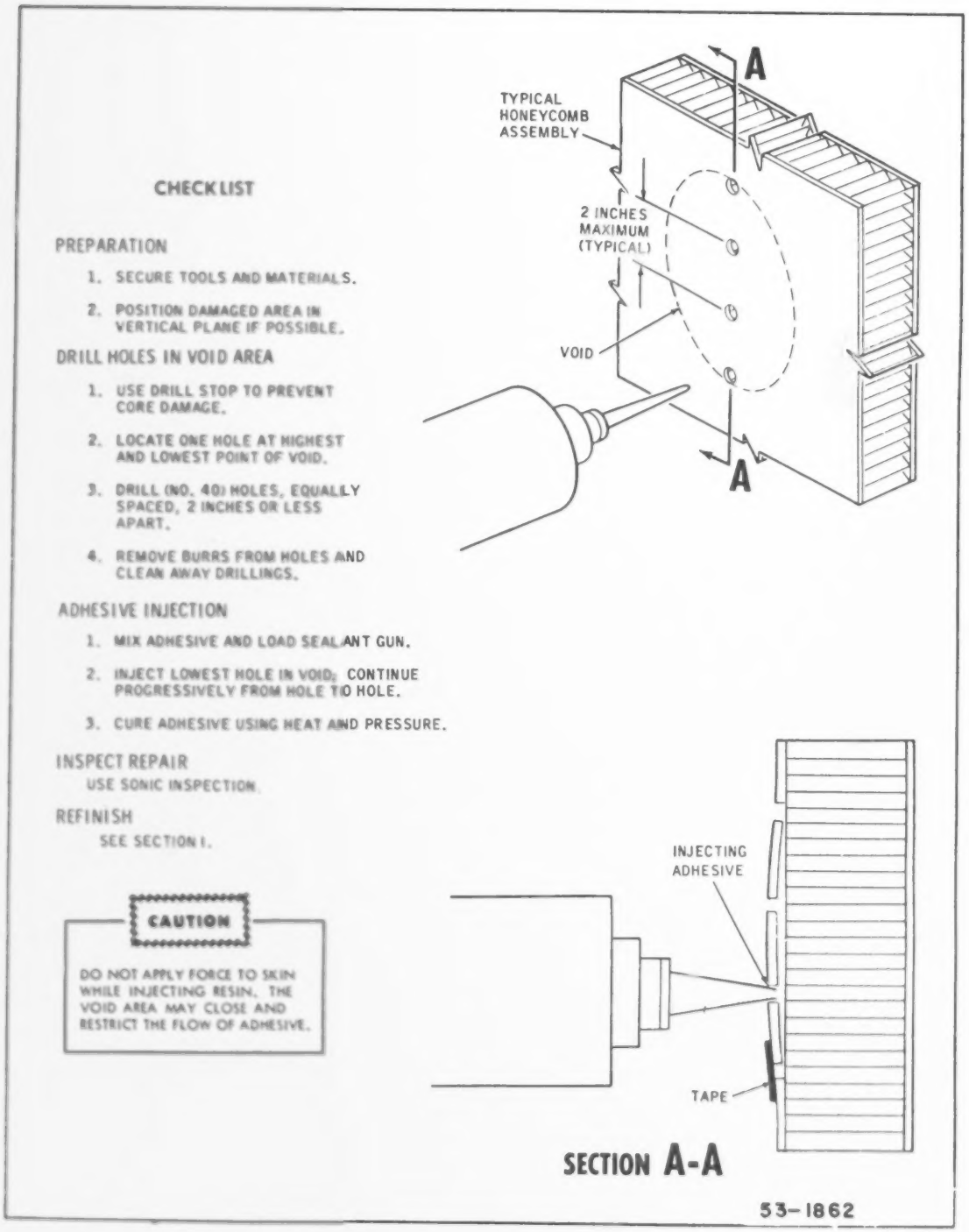

CHECKLIST
PREPARATION
1. SECURE TOOLS AND MATERIALS.
2. POSITION DAMAGED AREA IN VERTICAL PLANE IF POSSIBLE.
DRILL HOLES IN VOID AREA
1. USE DRILL STOP TO PREVENT CORE DAMAGE.
2. LOCATE ONE HOLE AT HIGHEST AND LOWEST POINT OF VOID.
3. DRILL (NO. 40) HOLES, EQUALLY SPACED, 2 INCHES OR LESS APART.
4. REMOVE BURRS FROM HOLES AND CLEAN AWAY DRILLINGS.
ADHESIVE INJECTION
1. MIX ADHESIVE AND LOAD SEALANT GUN.
2. INJECT LOWEST HOLE IN VOID; CONTINUE PROGRESSIVELY FROM HOLE TO HOLE.
3. CURE ADHESIVE USING HEAT AND PRESSURE.
INSPECT REPAIR
USE SONIC INSPECTION.
REFINISH
SEE SECTION I.
CAUTION
DO NOT APPLY FORCE TO SKIN WHILE INJECTING RESIN. THE VOID AREA MAY CLOSE AND RESTRICT THE FLOW OF ADHESIVE.
TYPICAL HONEYCOMB ASSEMBLY
2 INCHES MAXIMUM (TYPICAL)
VOID
A
A
INJECTING ADHESIVE
TAPE
SECTION A-A
53-1862

Figure 3-1-4. Minor skin delamination repair procedures.

Minor Skin Crack Repair Procedures. Minor cracks can be repaired by two methods. The first consists of stop drilling the cracks with a suitable diameter twist drill to eliminate stress concentrations at the ends of the crack. Then, either glass cloth overlays or a metal overlay is bonded over the cracked area, depending on TO specifications. The second method is basically the same except the cracked area is routed, and a filler is inserted, with the overlays being applied after. For purposes of our discussion, the method using glass cloth fillers and overlays is used.

Prepare the damaged areas requiring the glass cloth overlay repair by cleaning the surfaces, removing the damaged area using a template with router equipment, and cleaning out the damaged and surrounding area. After the damaged area has been completely removed and cleaned, the fillers and overlays are prepared. Two layers of fiberglass cloth, number 181, impregnated with fiberglass bonding adhesive are used as filler and overlay material. The filler layers are cut 1/16 inch smaller in diameter than the damage cutout. Before a laminated glass cloth overlay is applied to a repair area, clean the faying surface until no trace of foreign materials exists. Apply a thin and continuous film of adhesive primer EC–776R to the faying surface and let it dry at either room temperature or accelerated temperature as recommended. Then, place the overlays evenly over the repair area, extending at least 1½ inches beyond the edge of the damaged cutout. As an alternate to this repair procedure, three layers of fiberglass cloth, number 128, may be substituted for the filler and overlay layers. Then the repair is cured, tested, and surface finished.

Exercises (854):
Briefly state the reason for each given work procedure related to repairing minor cracks and delaminations.

1. Tilting the damaged assembly when injecting delaminated areas.

2. Using a drill stop, when drilling holes for injection of adhesives.

3. Removing all external pressures from the delaminated area.

4. Inject resins very slowly into the delaminated area.

5. Heat-forming of sealant gun tip.

6. Stop drilling the ends of cracks.

7. Cutting glass cloth overlays at least 3 inches larger than the cutout.

8. Applying heat to EC–776R adhesive primer.

855. Specify procedures for detecting and removing water that has accumulated in metal bonded honeycomb structures.

The existence of water in honeycomb assemblies is due to one or more of several factors. Failure of the seals at the ends of the assembly, improperly installed repairs, loose attachment fasteners, are just a few of the ways water gets into honeycomb assemblies. When water is found in a honeycomb panel assembly, it must be thoroughly dried before a repair is attempted. Drying is necessary to prevent freezing and corrosion damage, and to insure proper bonding of repair material.

Detection Methods. Three methods are used for detecting moisture in honeycomb panels: nondestructive inspections, visual, and by weighing. The last two methods are the methods you yourself can use to detect moisture. The first method requires the help of the Non-Destructive Inspection Shop.

The visual method consists of drilling a small hole at a low point in the assembly and checking for water seepage. If water is found, repair procedures are needed. When no water is located, reseal the holes using sealant MIL–S–8802.

The weighing method involves comparing the weights of a honeycomb panel, before and after it has been heated to 150° F. to 180° F. for 8 hours. It is essential that a vacuum of 20 to 25 inches of mercury be drawn in the panel during the baking process. The honeycomb core material must have perforated celles for the vacuum to have a moisture removing effect.

Preparing the Honeycomb Assembly. Water may be removed from the affected assembly while it is attached to the aircraft; taken off and worked on a bench or in special cases, put into a heated vacuum platen. The procedures to follow are:

a. Remove the end seals by cutting with a sharp pointed knife. Also remove one row of metal honey-

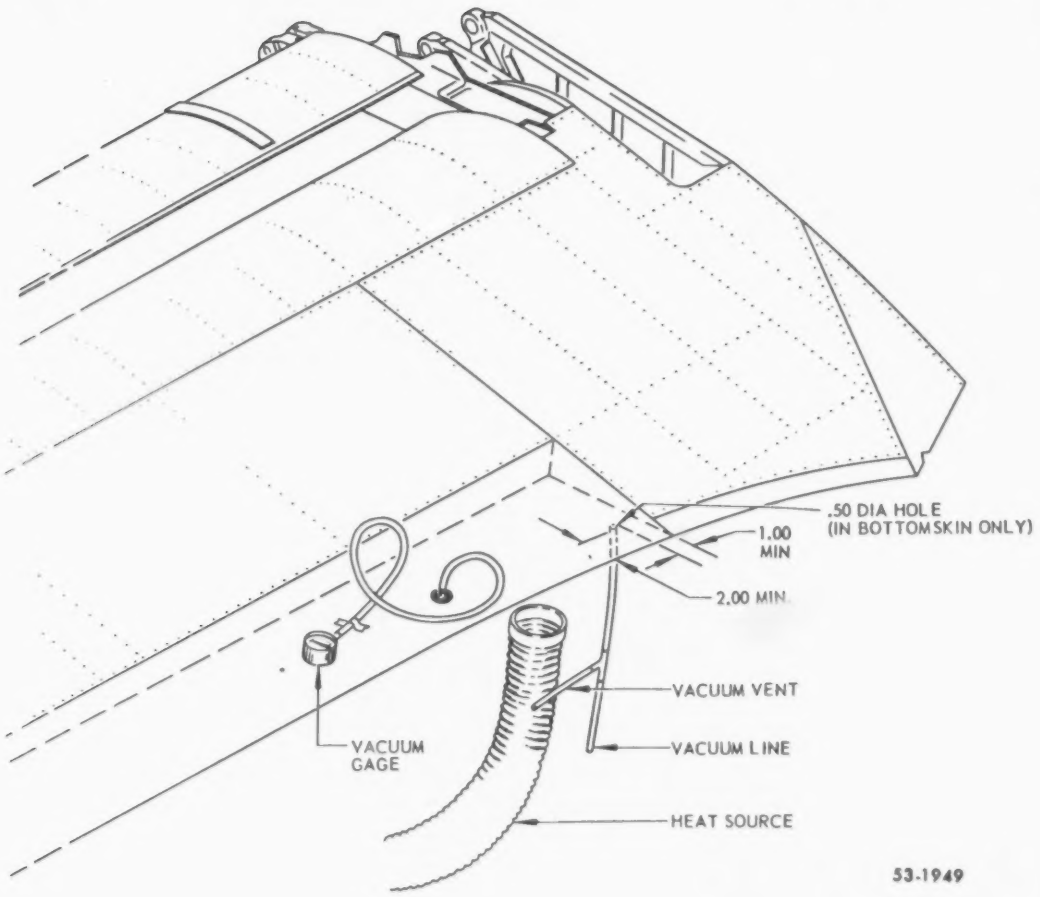


Figure 3-15. Water removal—open area insertion method.

comb core and adhesive flash, down to the plane of the tape adhesive on the skins. Do not attempt to remove the tape adhesive unless it is already detached from the skin. (NOTE: End seals are of a thin layer (.10" to .30") of environmental sealant, but occasionally an end seal will consist of a very hard epoxy that is not practical to remove by hand. This hard epoxy seal must be removed with a powered router.)

b. On large assemblies where it is impossible to get at the ends, or where water concentration shows up in the middle, cut a 1/2 inch diameter hole in one (and only one) skin, at least 1 inch from the assembly end, and 2 inches from the extreme trailing edge (fig. 3-15).

c. Place strips of double backed masking tape along the skin surface, over and under the area cut out, and also on the end seal in front of the area cut out.

d. Pack several layers of absorbent cloth in the area enclosed against the cell walls. Leave a small opening, approximately 2½ inches from the trailing edge for insertion of the vacuum tube.

e. Enclose these layers of cloth with a piece of PVA, PVC, or polyethylene film that has been cut to a suitable size, and stick it to the double backed tape, making a bag loose enough to allow for flexing under vacuum.

f. Cut opening in bag to allow entrance of vacuum line. Core should be cut back, at this point only, about 1/2 inch.

g. The vacuum line hook up to assembly (fig. 3-16), consists of a transparent vinyl tube 1/2" O.D. x 1/4" I.D. that goes from inside the assembly to vacuum source.

h. Fit a tee into the line about a foot away from the assembly and attach a small length of tubing for the release of vacuum. When vacuum is drawn, this outlet must be plugged with any suitable removable plug.

i. Test the bag at this stage for leaks; plug any leaks with Duxseal. Fit line through bag into honeycomb core, and with Duxseal make an airtight seal around bag.

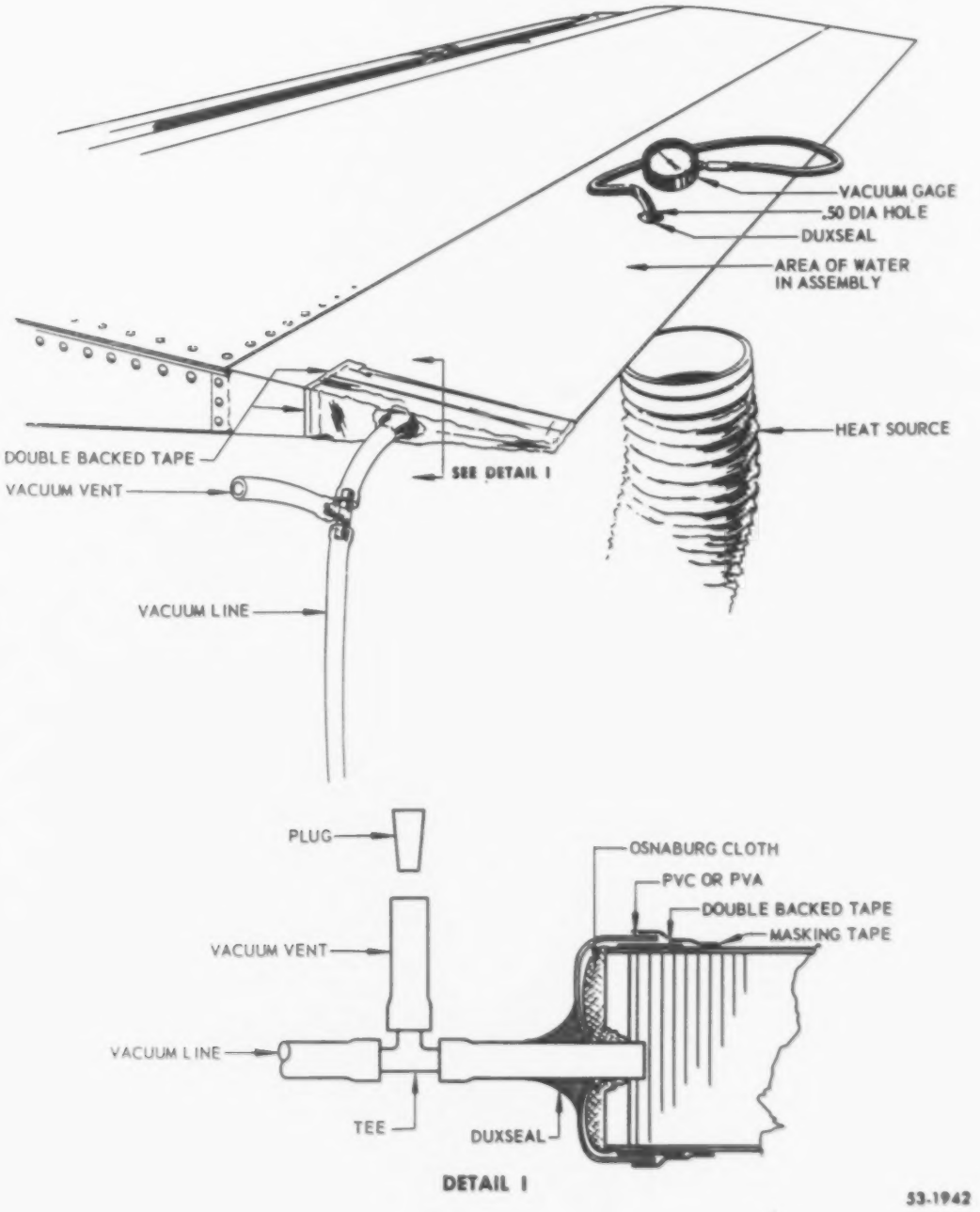


Figure 3-16. Water removal—edge insertion method.

855

j. Drill a 1/2 inch diameter hole in tab skin, above the area of greatest water concentration, and insert the tubing that is connected to the vacuum gage. Tube can be of any convenient length. Seal around the tube with Duxseal.

k. Apply heat below the area that has the greatest concentration of water. Heat lamps, portable heater, or heating blocks may be used as a source of heat.

Removing the Moisture. Once your vacuum procedure are completed, you are ready to apply heat and vacuum pressure to remove the water. The procedures are as follows:

a. Heat the area containing water for about 15 minutes or until a temperature of 180° F. is reached. Templestiks or Templaks may be used to indicate temperature.

b. Start vacuum source and draw a steady vacuum to a maximum of 20 inches hg. If gage reading is below 10 inches hg., check the vacuum bag for excessive leakage. NOTE: The amount of vacuum pressure required may differ from one honeycomb assembly to another. Always consult the specific -3 TO.

c. Leave heat and vacuum on assembly for one hour. Water being extracted from assembly can be noted by water droplets appearing in the transparent vinyl tubing.

d. When water appears to have ceased coming out of the assembly, a rocking type action shall be given to the air flow by removing the plug on the Tee section and alternately opening and closing the line with the finger until no more water appears to be drawn out.

e. An x-ray picture should be taken at this time to determine the amount of water left in the assembly. When the x-ray shows that about 90 percent of the water has been removed, and no dense pockets that could cause damage by freezing are left, the operation is stopped. NOTE: A dense pocket is 5 or more adjacent cells containing water.

Exercises (855):

1. How should you detect water in a honeycomb assembly using the visual method?

2. How long and at what temperature is the weighing detection method conducted?

3. How should hard epoxy end seal be removed when setting up a vacuum pressure moisture removal operation?

4. In cases where it is impossible to get at the ends of a structure containing water, where should the vacuum set-up hole be drilled?

5. When using a vacuum pressure to remove moisture, what is the maximum amount of pressure and heat to be applied and for how long?

6. When is a panel determined to be free of moisture damaging concentrations?

856. Supply the missing repair procedures used to make a potting compound repair to metal bonded honeycomb panels.

You may repair a bonded honeycomb structure up to 1 inch in diameter by the hole-filling technique, using approved materials. The repair method is commonly known as the potter compound repair. It is the easiest and fastest method that you can use to mend a damaged area of a bonded honeycomb structure. However, you must adhere to the techniques, methods, or procedures established for potted compound repairs. Not following prescribed procedures during your repair may complicate the situation by creating additional damage. Potted compound repairs may be applied to both single-face (one skin) and core damages, and to double-face (two skins) and core damages. (See fig. 3-17).

Surface Preparation. Scrub aluminum skin with MEK to remove surface contaminants. Use no paint stripper or remover in the repair area. Lightly sand surface of the aluminum skin with 400 grit abrasive cloth to remove surface oxides, etc., but without penetrating the clad surface. The surface should be wiped with clean gauze pads moistened with MEK after the

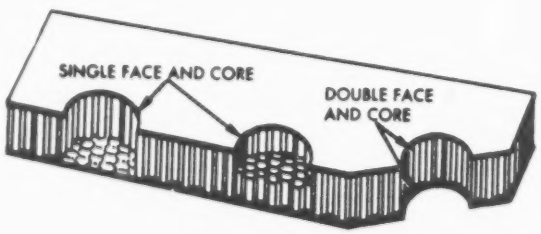


Figure 3-17. Typical potting compound repair areas.

sanding operation to remove any traces of foreign material. Do not allow MEK to dry, but wipe off with a clean dry cloth.

Damage Removal. Damages 1/4 inch or less in diameter may be satisfactorily removed with a twist drill. The multitemplate and a high-speed router (10,000 to 20,000 rpm) are used in the removal of damaged area for potted compound repairs up to 1 inch in diameter. The amount of material removed by either method must be kept to a minimum in order to maintain as much of the original strength of the panel or structure as possible. Always use a face mask or goggles when using the router to remove damaged materials.

Repair Parts Setup. After a damaged area has been completely removed and cleaned, the necessary materials for the potted compound repair(s) are prepared. Pieces of sheet plastic materials are prepared to provide a smooth surface effect on the potted compound repair to provide part of the reservoir for the hole-filling operation of the repair and to hold the potting compound in place until it is completely cured. The pieces of sheet plastic used for any of these purposes should be at least 1/2 inch larger in diameter than the diameter of the hole to be repaired.

Apply a thinner piece of sheet plastic material (approximately 1/16 inch thick) to the lower (bottom) surface of the double-face repair. (See fig. 3-18.) This is done not only to give the repaired surface a smooth effect but mainly to hold the repair surface (potting compound) in place until it is cured. The same process may be used with a single-face repair where the work must be done in an overhead position.

Sheet plastic materials ranging from 1/4 to 3/16 inch in thickness are used on the upper surface of the repair during the hole-filling procedures. A 1/4-inch hole is drilled directly in the center to permit easy application of the potting compounds to the repair cavity. The hole is also countersunk to allow a buildup of the potting compound and thus to assure that the repair cavity has been completely filled.

This piece of plastic material is also a part of the "Duxseal" dam. After the prepared pieces of sheet plastic materials are properly located and taped in place over the repair area. the Duxseal dam is built up around the hole. (See fig. 3-18.) This dam is partially filled with the potting compound during the hole-filling operation to insure that the cavity of the repair is adequately filled. The Duxseal dam also acts as the reservoir.

Hole Filling Procedures. Next, prepare a sufficient batch mix of the preferred (Epon 815 curing agent T and microballoons) potting compound or its alternate (fiberglass adhesive and microballoons) compound for the repair. Fill the cavity with the potting compound and remove the air bubbles with a toothpick or similar tool. By removing the air bubbles, you make sure that the cavity is solidly filled.

When the potting compound in the repair cavity is completely cured, remove the pieces of plastic. Generally, these pieces are lifted off by hand. If necessary, you may pry them off easily with any dull, straight handtool. When you remove the drilled top piece of plastic, a broken stem will be left protruding above the repair surface. This stem may be filed, microshaved, or routed down to make the repair surface smooth.

Surface Overlay Procedures. All potted repairs require the use of either glass overlays or a metal overlay. The surface should be primed using adhesive primer EC-776R. The adhesive should be brushed on to all faying surface area and allowed to dry before applying the overlays. Drying time required is approximately one hour at room temperature 22° C. (72° F.). The drying may be accelerated by the application of heat not to exceed 66° C. (150° F.). The adhesive primer should be applied in as thin and continuous a film as possible. Do not attempt to thin the primer. Room temperature should be maintained at between 65° F. and 70° F. with humidity below 65 percent to insure proper bonding.

Once the surface has been primed, then the glass cloth overlay or metal overlay is placed evenly over the repair area, extending at least 1½ inches beyond the cutout area. Then the repair is cured tested and the surface refinished.

Exercises (856):
The following listings of work procedures used when making a potting compound repair, contain missing procedures. Write-in the missing work procedures.

1. Core Filling Procedures

   a. Scrub aluminum skin with MEK.

   b.

   c. Wipe surface clean using cloths moistened with MEK.

   d. Remove damaged core material.

   e.

   f.

   g. Place thick plastic sheet on the upper surface.

   h. Drill 1/4 inch hole in plastic (thick sheet).

   i. Prepare "Duxseal" dam.

   j.

   k. Fill repair cavity with potting compound.

   l.

   m. Cure potting compound.

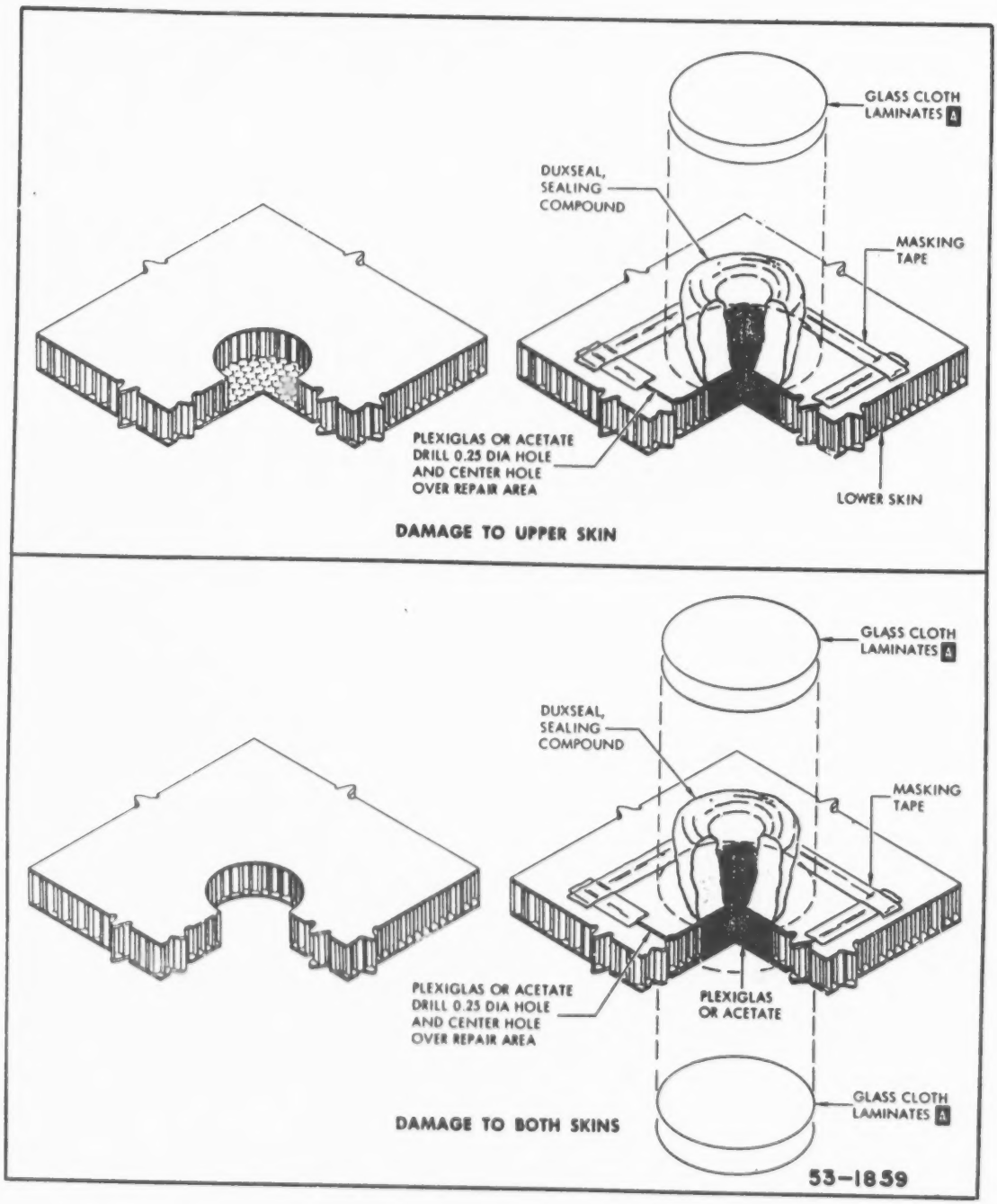

GLASS CLOTH LAMINATES A
DUXSEAL, SEALING COMPOUND
MASKING TAPE
PLEXIGLAS OR ACETATE DRILL 0.25 DIA HOLE AND CENTER HOLE OVER REPAIR AREA
LOWER SKIN
DAMAGE TO UPPER SKIN
GLASS CLOTH LAMINATES A
DUXSEAL, SEALING COMPOUND
MASKING TAPE
PLEXIGLAS OR ACETATE DRILL 0.25 DIA HOLE AND CENTER HOLE OVER REPAIR AREA
PLEXIGLAS OR ACETATE
GLASS CLOTH LAMINATES A
DAMAGE TO BOTH SKINS
53-1859

Figure 3-18. Potting compound repair techniques.

n.

o. Sand repair area smooth.

2. Overlay Procedures

a. Prime surface with EC-776R and let dry.

b.

c. Cure repair area/remove heat and vacuum equipment/sand smooth.

d.

e. Replace surface finish.

857. Distinguish true from false statements related to making a metal bonded honeycomb repair involving the replacement of core material, and correct the false statements.

When damages to metal bonded honeycomb panels exceed the allowable limits for potting repairs, the core material must be cut out and replaced, and th addition made of metal or glass cloth overlays, except in cases where the repair area must be flush.

Core Preparation Procedures. Figure 3-19, shows a typical repair used when both core facings and core have been damaged. Since previous discussion covered the removal of the damaged core material and the preparation and placement of glass cloth laminates, our discussion here will center on the preparation and insertion of the core material.

Glass fabric honeycomb core plugs. Glass fabric honeycomb core replacement plugs should be fabricated from fabric honeycomb material (grouped in MIL-C-8073) cut to the size of the repair cavity and to a thickness that it will be within flush to 0.010 of an inch of the surface.

The thickness of the plug should compensate for both the removed facings and old bondlines when nonflush repairs are being installed. Bondlines should be assumed to be 0.004 to 0.006 of an inch thick. The correct thickness and contour may be obtained by cutting the glass fabric honeycomb material with a saw and/or sanding. Prior to application of the potting compound or adhesive, clean the plug by immersing and agitating it in MEK for 1 to 2 minutes, followed by air drying for 15 or 30 minutes.

Aluminum honeycomb core plugs. Aluminum honeycomb used for core plugs should have a cell size equal to or smaller and density greater than that being repaired. When a trailing edge section is being repaired, cut the core plug to shape the cell walls normal to the repaired skin. Bondlines should be assumed to be 0.004 to 0.006 of an inch thick. Cut aluminum honeycomb plugs approximately 0.0156 of an inch larger than the repair cavity. NOTE: If aluminum honeycomb core material is used in the repair (shown in fig. 3-19), metal overlays are required.

Insertion Procedures. The type of adhesive used to bond the replacement core indicates the procedures to use during insertion of the core plug. When using a potting compound, coat ("butter") the core plug on all contacting (faying) surfaces and the repair cavity. In addition, for single-face repairs, the potting compound may be injected into the damaged core area. This insures a sound bonding area for the core plug within the repair area. After the core plug has been properly installed in the repair area, the excess potting compound is removed with a plastic scraper and the surface area thoroughly cleaned with MEK.

When using a foam tape adhesive, apply the specific thickness of form tape to the periphery and repair cavity of the plug and core. Lightly press the foam tape into the cells, then insert the core plug into the repair cavity. The cell direction of the plug should be the same as the core.

Exercises (857):

1. Identify true and false statements by placing the letter "T" or "F" in the space provided.

___ a. Only single-face core replacement repairs require overlays.

___ b. Replacement core plugs thickness should include allowances for old bondlines.

___ c. Glass cloth replacement core plugs should have cells equal to the original core material.

___ d. Cleaned glass cloth replacement core plugs should be primed using EC-77CR.

___ e. Aluminum replacement core plugs used in a trailing edge repair should be perpendicular to both skins, when milling equipment is available.

___ f. Old bondlines are considered to at least 0.006 of an inch thick.

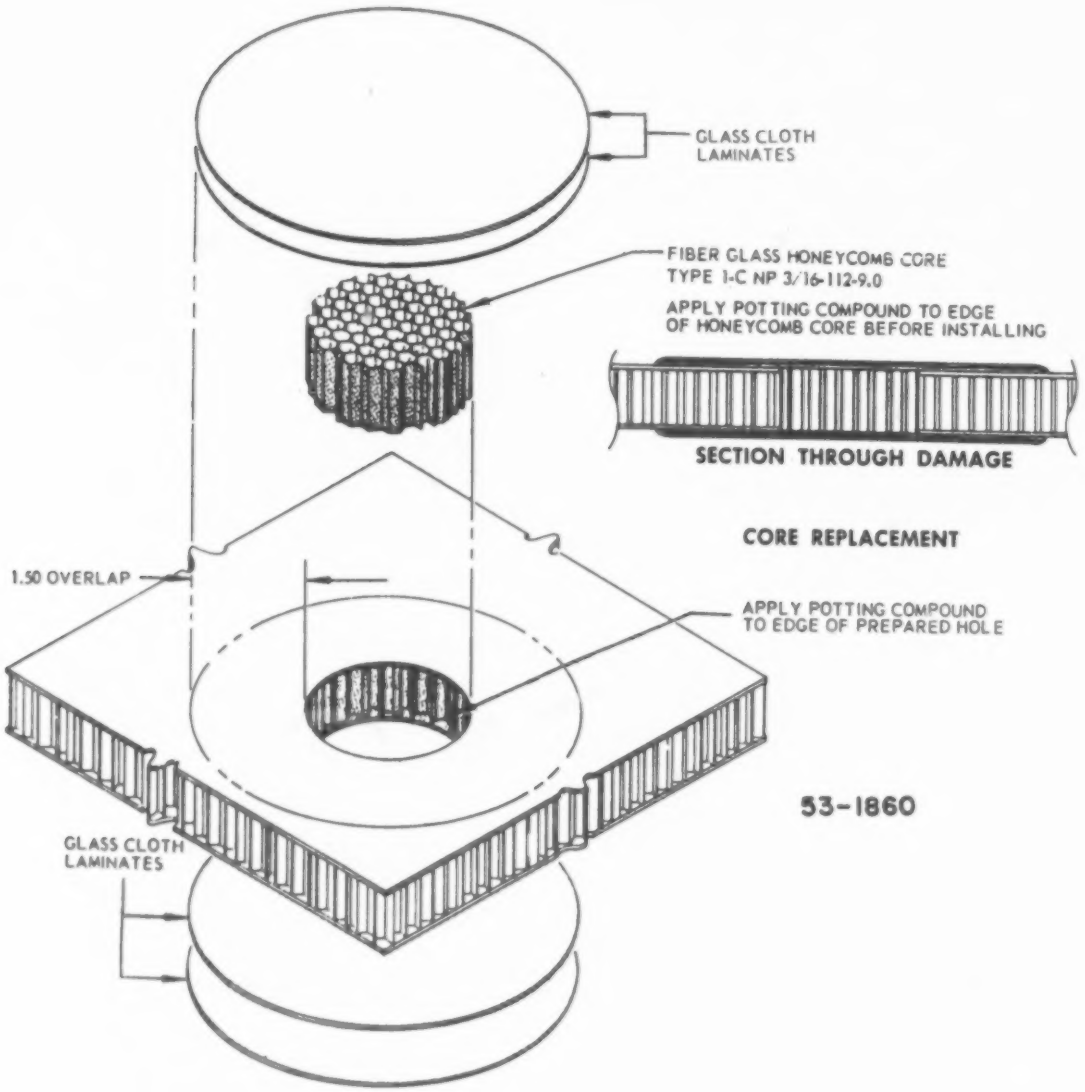

GLASS CLOTH LAMINATES
FIBER GLASS HONEYCOMB CORE TYPE 1-C NP 3/16-112-9.0
APPLY POTTING COMPOUND TO EDGE OF HONEYCOMB CORE BEFORE INSTALLING
SECTION THROUGH DAMAGE
CORE REPLACEMENT
1.50 OVERLAP
APPLY POTTING COMPOUND TO EDGE OF PREPARED HOLE
53-1860
GLASS CLOTH LAMINATES

Figure 3-19. Metal bonded honeycomb repair—both facings and core.

___ g. Aluminum replacement core plugs are cut to match the repair cavity cutout.

___ h. Only the replacement core plug is "buttered" with potting compound.

___ i. The cell direction of the replacement core plug should be the same as the original core.

___ j. Foam tape adhesive is applied only to the replacement core plug.

2. Based on your answers to exercise 1, state the correct procedures for all false statements.

858. Indicate whether given statements related to procedures used to prepare metal parts for metal bonded honeycomb repairs are correct, and correct the false statements.

Repair Part Preparation. As with any repair, certain specific procedures must be used to insure a properly repaired part. When making bonded repairs involving the use of metal patches, doublers, filler plugs, and core separators, use the following guidelines.

Skin patches. All metal patches for aluminum honeycomb panels are made from the same aluminum alloy sheet thickness as the skin being repaired, unless specified differently to TO specifications. The length of the patch, when not a circular pattern, should not be more than twice the width. When preparing patches, determine the length of the patch first, then design the width to one-half of the length.

Prepare non-flush skin patches and doublers using the same material thickness as the skin being repaired, unless specified differently by TO specifications. The width of the overlap of non-flush patches and doublers must be such that the bonded area will have sufficient shear strength to obtain the ultimate tensile strength of the original structure. The amount of overlap required is determined by the thickness and material of the honeycomb panel skin being repaired. Ascertain the skin thickness and material, then calculate the required lap width for that thickness and material. Corners should be rounded to 0.25 minimum radius, and all edges should be free of burrs and beveled.

Flush patches. When flush skin patches are required, the material thickness shall be 0.004 to 0.006 inch thicker than the skin being repaired to compensate for the original bondline thickness. The patch should be prepared to fit the cutout area to within +0.000/-0.030 of an inch tolerance. Flush patches should be supported by an internal doubler.

Core separators. A core separator is required when not all of the core material will be removed. The core separator must be the same material as the skin except the thickness may vary according to TO specification. The tolerances for core separators must be within +0.000/-0.030 inch of the hole size of the cavity of the honeycomb core.

Surface Preparation. To insure good adhesion, it is essential that all metal surfaces to be bonded are alodized. When a surface conditioner, such as Epon 927, is going to be used, it should be applied within 8 hours after cleaning to 0.001 of an inch thick coat. Cure primer for 2 hours at 76° C. to 88° C. (170° F. to 190° F.). Patches primed with Epon 927 surface conditioner may be stored for a maximum of 180 days before use. When patches are to be stored, 3M-347 or 3M-344 type should be applied to the primed surface, wrap them with clean brown wrapping paper and tape to seal out possible contamination.

If a patch has been stored, and is ready for use, remove tape and scuff primer lightly with fine aluminum oxide abrasive paper. Remove loose materials with a clean cloth dampened with MEK. NOTE: Wear clean white cotton gloves at all times when you handle clean parts.

Exercises (858):

1. Indicate in the space provided, whether a statement is correct or incorrect by writing-in the work "yes" or "no."

___ a. The width of skin patches used on aluminum honeycomb panels should not be more than twice the length.

___ b. The amount of overlap required when fabricating doublers is determined by the cell size of the original panel.

___ c. Metal flush patches should be equal to the original skin thickness.

___ d. Metal patches that have been primed with Epon 927 can be stored for 120 days.

___ e. Core separators are required when all of the core material is removed.

2. Based on your answers to exercise 1, make the necessary corrections to all incorrect statements so they will read correctly.

859. Differentiate between the repair techniques used when making repairs to metal bonded honeycomb panels requiring the use of metal repair parts.

The earlier repairs shown in this section either required the use of glass fabric overlays. The following

repairs illustrate techniques used when metal repairs, such as, overlays, filler plugs, doublers, and core separators are required. Also discussed are the procedures for preparing an adhesive with a binder (cheesecloth).

Flush Repair. Take a few minutes to study figure 3-20. Notice that the repair parts are different from those previously discussed. With this repair, the top surface of the repair area must be flush with the skin surface.

Damage removal. Before removing the damage area, thoroughly clean the area around the damage to a minimum of 4 inches from the damaged area. The routing template should be large enough to remove the damage without exceeding repair limitations. First adjust the router to remove the skin, then readjust it to remove the damaged core.

Fabrication of repair parts. The internal doubler (core separator) is fabricated from 0.003 of an inch aluminum foil, while the filler patch is made from the same material (7075–T6) and thickness as the skin. Both the internal doubler and filler patch should be equal to the diameter of the cutout hole, minus 0.01 of an inch. The core plug should be the same diameter as the cutout area in order to provide a snug fit. Also, it must be thick enough to be flush with the inner surface of the skin.

After the repair parts are cut to required size, sand both sides of the internal doubler and the faying surface of the filler patch to a bright, shiny surface with No. 400 grit emery sheet. Clean the parts with MEK. As with the previously discussed repairs, you should wear clean, white cotton gloves to handle the repair parts after cleaning. If the core edges were bent during the cleaning, straighten the edges before proceeding with the repair.

Adhesive preparation. When using cheesecloth as a binder for an adhesive, place a piece of cheesecloth on a flat surface covered with cellophane. Pour a small quantity of adhesive onto the cheesecloth and place a second piece of cellophane over the adhesive. Work the adhesive into the cheesecloth with the edge of a spatula. After the cheesecloth is impregnated, place an internal doubler on the cellophane covered cheesecloth and cut around it with a sharp knife. Then remove the cellophane from the impregnated cheesecloth and cover one side of the internal doubler. Then wrap the core plug (sides and bottom) with impregnated cheesecloth. Do not overlap the cheesecloth on either the upper or lower surface of the core plug.

Insertion of repair parts. Before inserting the repair parts, coat the sides and bottom of the cutout with adhesive. Place the internal doubler into cavity with cheesecloth in contact with the core. Then insert the plug into cutout with cheesecloth against the internal doubler. Finally, coat the inner surface of the flush patch with adhesive, cover with adhesive-impregnated cheesecloth, place the patch on top of plug, and press in place. Remove any excess adhesive.

Curing process. For curing, use a vacuum and pressure set-up. Maintain heat and pressure for the time required to cure the repair. After curing, inspect the repair for an effective bond, clean the area, and refinish to TO specifications.

Non-Flush Repair. Figure 3-21, illustrates the procedures used for making a non-flush repair. The main difference between this repair and the flush repair, is the addition of the external patch. Usually the external patch is fabricated from one gage heavier material than the original skin thickness. As for the amount of overlay required, this is determined by the thickness of the original skin thickness. Before placing the external patch in position, coat the faying surface with adhesive, and cover with adhesive-impregnated cheesecloth. Cure this repair as previously described for the flush repair.

Combination Repair. Figure 3-22 illustrates the procedure to be used when a repair must be flush on one side and can have an external doubler on the other side. The main differences between this repair and the previous discussed repairs (flush and non-flush) are the method of skin cutout on the side required to be flush and the positioning of the internal doubler.

When making the cutout, remove all the damaged to both facings and core. After the damaged materials are removed, an additional 1 inch of core material and the inner facing are removed from around the original cutout. This action produces the necessary opening for positioning the internal doubler, as shown in figure 3-22. When making the second cutout, be sure not to cut into the bondline on the outer skin.

Exercises (859):
At the end of each statement, write in the type of metal repair referred to in the statement.

1. Requires only two metal repair parts of the same diameter.

2. Core replacement plug is much larger than that of the original damaged core area.

3. A skin filler plug is not required.

4. Requires three metal repair parts.

5. Requires the least amount of impregnated cheesecloth.

2.5
2.8
2.2
3.2
3.6
2.0
4.0
100 mm
1.0
1.1
1.25
1.4
1.6
1.8
2.8
3.2
3.6
4.0
2.5
2.2
2.0
ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
1234567890
1.0 mm
1.5 mm
2.0 mm
A5

CHECK LIST

PREPARATION

1. SECURE TOOLS AND MATERIALS.
2. REMOVE PAINT.

REMOVE DAMAGED SKIN AND CORE

1. POSITION HOLE ROUTING TEMPLATE.
2. REMOVE DAMAGED MATERIAL USING PROPER ROUTING PROCEDURE.

FABRICATE REPAIR DETAILS

BONDING

1. CLEAN REPAIR AREA AND DETAILS.
2. MIX ADHESIVE.
3. APPLYY ADHESIVE—USE IMPREGNATED CHEESECLOTH AS REQUIRED.
4. CURE ADHESIVE USING HEAT AND PRESSURE.

INSPECT REPAIR

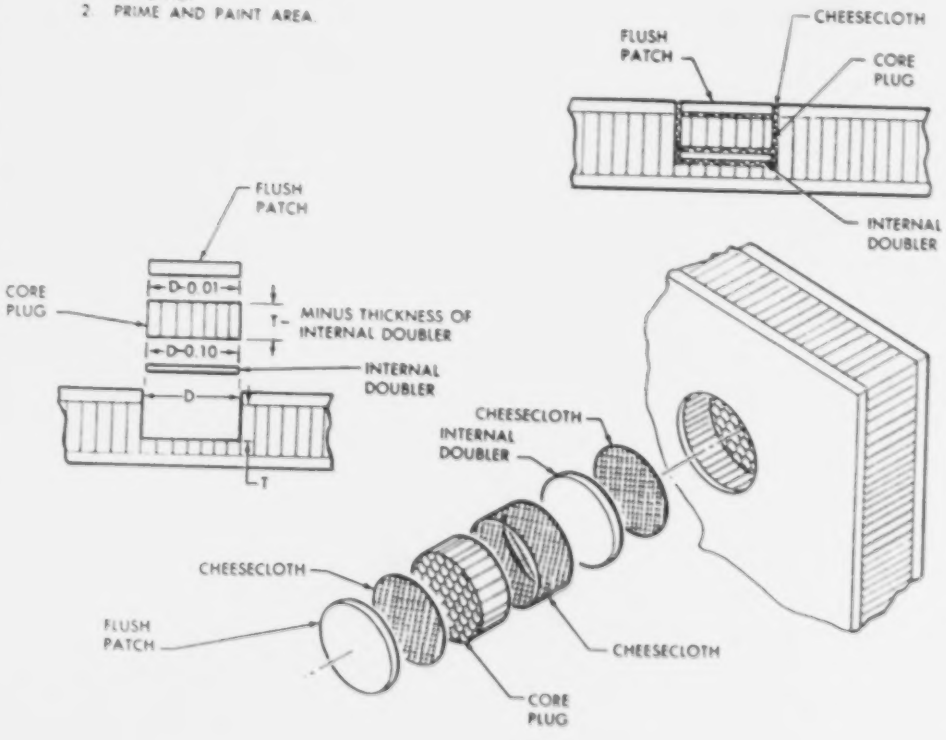
REFINISH

1. REMOVE ADHESIVE FLASH BY SANDING.
2. PRIME AND PAINT AREA.

REPAIR MATERIALS		
REPAIR COMPONENTS	**MATERIAL**	**SPECIFICATION**
FLUSH PATCH	ALUMINUM	7075-T6 ALCLAD SAME GAGE AS SKIN
CHEESECLOTH		
CORE PLUG	HONEYCOMB	NYLON PHENOLIC 3/16-112-4.5
INTERNAL DOUBLER	.003 ALUMINUM FOIL	

Note

SEE COMPONENT REPAIRABLE DAMAGE EVALUATION FOR MAXIMUM D DIMENSION



53-1861

Figure 3-20. Metal bonded honeycomb repair—flush repair.

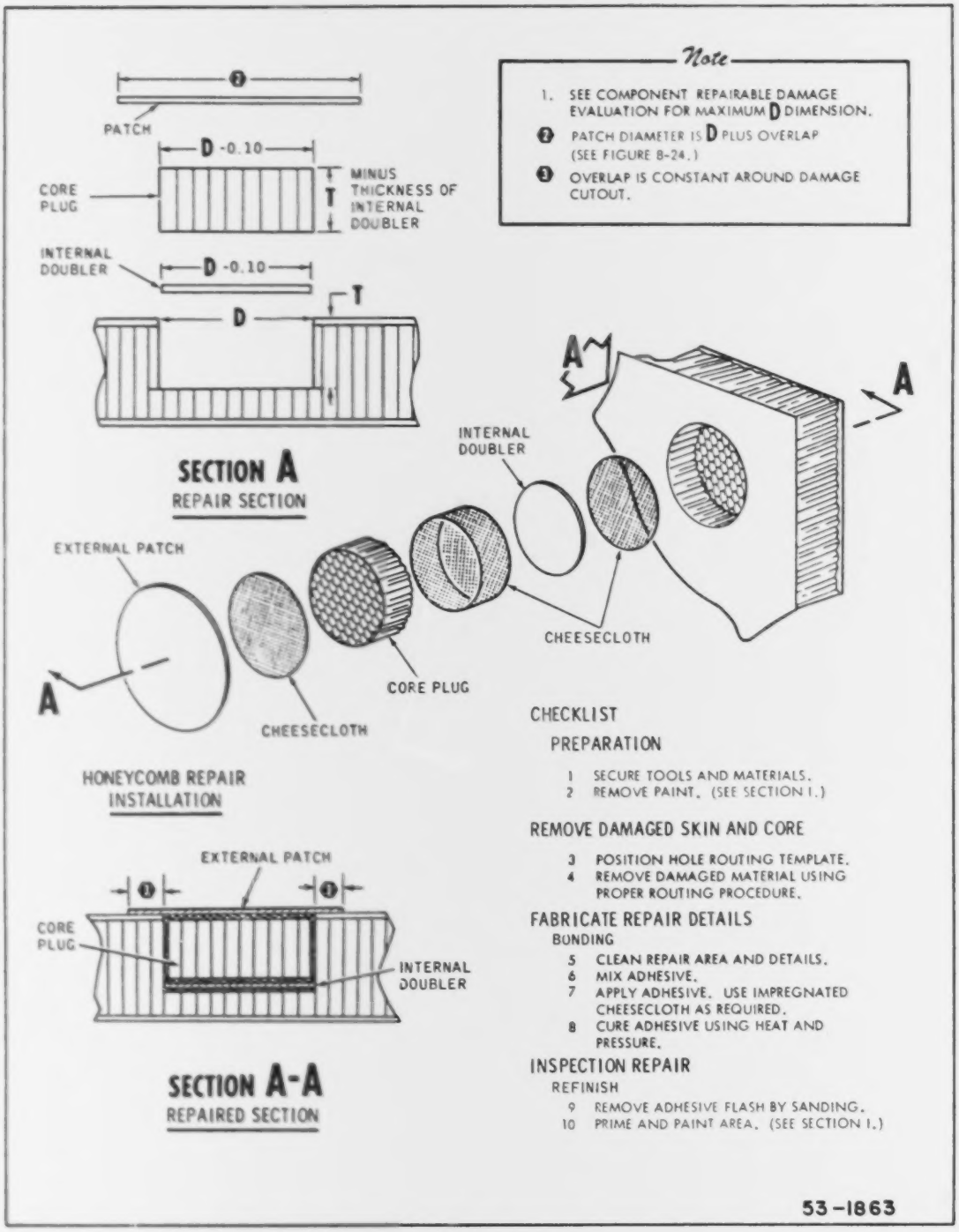


Figure 3-21. Metal bonded honeycomb repair—non-flush repair.

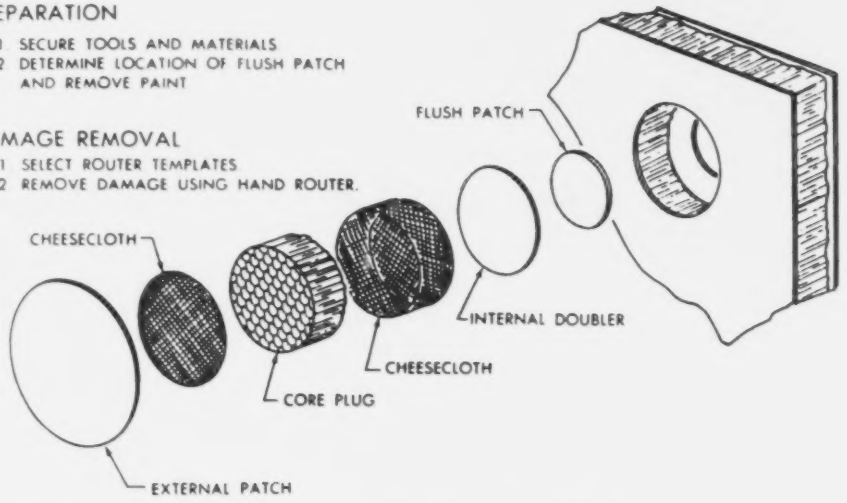
CHECKLIST

PREPARATION

1. SECURE TOOLS AND MATERIALS.
2. DETERMINE LOCATION OF FLUSH PATCH AND REMOVE PAINT.

DAMAGE REMOVAL

1. SELECT ROUTER TEMPLATES.
2. REMOVE DAMAGE USING HAND ROUTER.



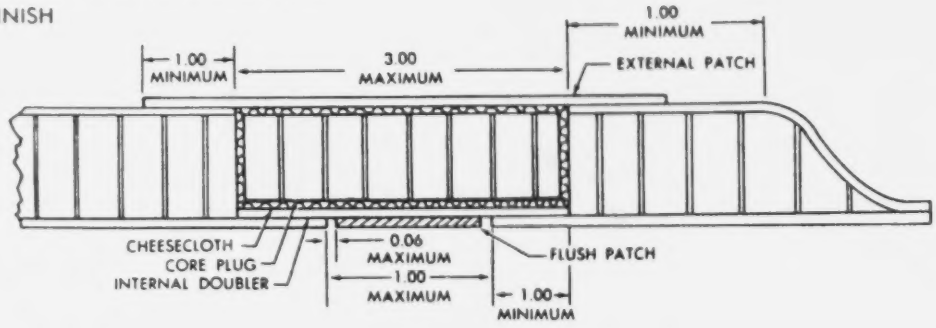
REPAIR ASSEMBLY

1. FABRICATE REPAIR DETAILS.
2. CLEAN AREA AND DETAILS.
3. APPLY ADHESIVE.
4. ASSEMBLE DETAILS USING ADHESIVE IMPREGNATED CHEESECLOTH AS REQUIRED.
5. CURE ADHESIVE USING HEAT AND PRESSURE ON BOTH SIDES.
6. INSPECT REPAIR FOR EFFECTIVE BOND.

Note

THIS REPAIR CAN BE INSTALLED WITH THE FLUSH PATCH ON EITHER THE INNER FACE OR THE OUTER FACE, UNLESS THE NON-FLUSH PATCH IS IN AN AREA WHERE IT WILL INTERFERE WITH THE MAIN GEAR MECHANISM.

REFINISH



REPAIR MATERIAL	
DESCRIPTION	**MATERIAL**
DOUBLER	0.040 SHEET ALCLAD 7075-T6
PATCH	
CORE PLUG	3/16-112-4.5 NYLON PHENOLIC HONEYCOMB CORE

53-1864

Figure 3-22. Metal bonded honeycomb repair—combination (flush and non-flush).

860. Correlate material size requirements with the size of the damaged cutout area.

Repair of Transition Area. The edge section of a bay area in which the honeycomb structure joins the laminated edge of the panel or section is known as the transition area. Effective repairs to the transition areas are particularly essential because of local transference of the stresses. You should consult the applicable section of the -3 technical order for making repairs on a specific type of aircraft.

The repair to a damaged panel transition area is basically the same as any other bonded honeycomb skin and core repair. The differences you will find are in the process used in the removal of the damaged area and preparation and application of the repair core plug. (See fig. 3-23).

The techniques involved in the preparation for the removal of a damaged panel transition area are similar to those you have previously studied. The only exception is that the routing template must be bridged on one edge to allow for construction features of bonded honeycomb panels and their bays. The bridge consists of a wooden block equal to the necessary height required to support and prevent the routing template from tilting or rocking during the routing operations. The routing template must be bridged in this manner to serve as a guide so that the cutout of the damaged area is exactly parallel with and perpendicular to the surface. This simplifies the fitting of the repair core plug.

The preparation of the repair materials, assembly, and curing of the core plug are the same as those used for bonded honeycomb skin and core repairs. However, because of the shape and contour of the transition area (especially at the corners of a bay), special attention must be given to the cutting and shaping of the glass fabric honeycomb core material to insure that it will fit properly where the repair core plug is needed.

Repair of Trailing Edge Area. Damage to the trailing edge of an honeycomb panels is one of the most common damages that you will encounter in the bonded honeycomb structures. Most instances of damage occur at the extreme edges where the upper and lower facings meet, the damages extending into the core material. A typical tapered, double-face repair has been developed for this particular type of damage. Two typical damage cutouts have also been developed and are shown in figure 3-24. The manner in which damages normally occur to the trailing edge of honeycomb panels or section makes adjoining areas susceptible to delamination; therefore, the adjoining areas should be closely inspected to insure a true evaluation of the damage. Any delaminations detected are considered part of the damage and repaired accordingly.

One of the more important factors that will help you to complete an acceptable repair is cleanliness. When preparing a damaged area for repair, you must insure that the adjoining areas are free of all foreign matter. The surface area extending several inches from the edge of the damage must be clean. This is done to provide a clean surface for the adhesion of the double-backed tape, used to hold the routing template in place and to insure bonding of the adhesive.

When the extent of damage has been determined, a routing template of a desired shape and size is selected. It should be of a size and shape that would permit the smallest damage cutout possible, yet allow for the complete removal of all the damaged area. The template may be of a multitype design or one manufactured locally. The routing operation is a simple task, similar to repairs already studied.

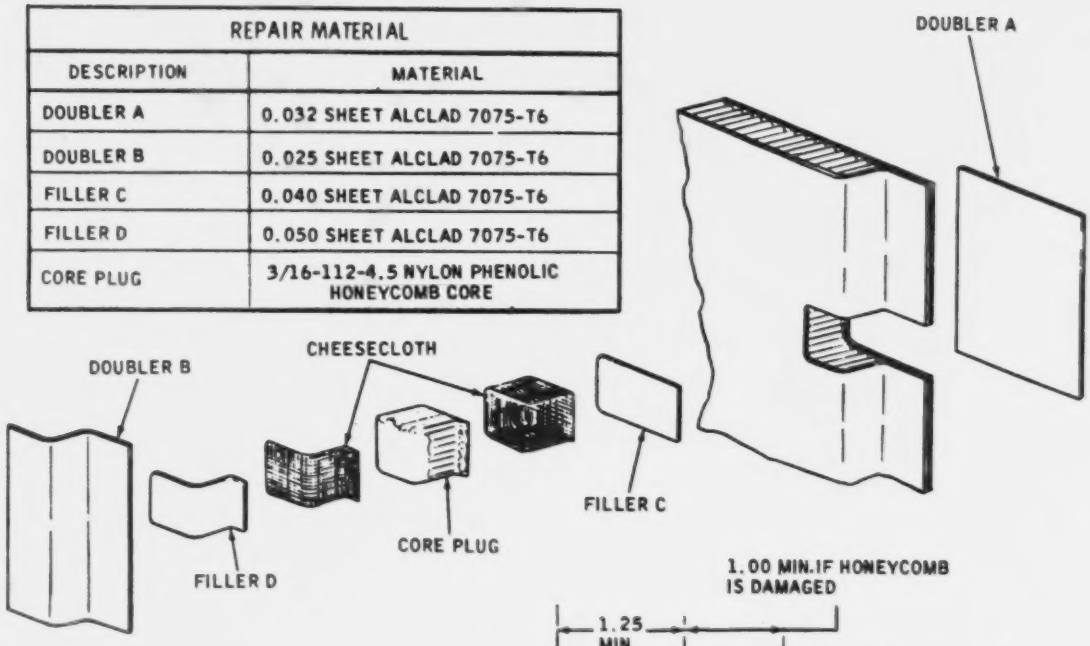
A core plug for the tapered trailing edge repair is prepared from a piece of 3/16-inch cell size class fabric honeycomb core material. It is cut and sanded to the shape required to match the taper of the repair area within a tolerance of ± .010 inch. The only exception to this tolerance is that the core plug is cut shorter (1/4 to 3/8 inch at the extreme tapered tip). This permits a buildup of the adhesive at the tip of the trailing edge in order to form the shape of the original design.

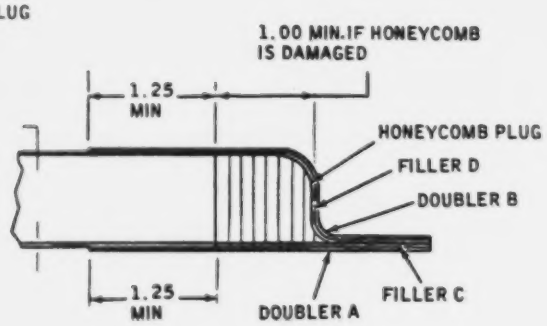
Before inserting the core plug in the damage cutout, be sure to "butter" all contacting (faying) surfaces of the core plug and the edges of the cutout with an application of the potting compound. A pressure jig is attached to the lower surface of the repair area to hold the core plug in place until it has been allowed to cure at room temperature for 30 to 40 minutes. The curing stabilizes the core plug and permits the removal of all extra support so that you may complete the job.

Before the repair area is allowed to cure, remove the excessive potting compound with a plastic scraper. Then reclean the area with MEK. Glass cloth overlays for the tapered trailing edge repair are cut either of number 181 fiberglass or its alternate, number 128, and then impregnated with bonding adhesive. The pieces are cut at least 3 inches larger than the repair area. This allows for the required minimum overlap of the overlay — that is, 1½ inches beyond the edge of the damage cutout. Two layers of impregnated number 181 cloth (three if number 128 is used) are used as overlays for each surface of the repair. The first overlay is fastened to the lower surface of the repair and held in place with a polythylene film covered sheet of aluminum that acts as a pressure jig. For this type of repair, the pressure jig is made to extend approximately 2 inches beyond the trailing edge, thus providing space for buildup of the adhesive, an excessive deposit of which is necessary to fill up the trailing edge tip to its original shape and thickness.

After the overlay for the lower surface of the repair is secured in place, the second overlay is evenly applied to the upper surface. Check the edge of the repair at this point to make sure that a sufficient amount of adhesive has been deposited to build up the trailing edge. Place a sheet of polythylene film, slightly larger than the overlay, over the upper overlay to allow for an even removal of the excess adhesive and of air

REPAIR MATERIAL	
DESCRIPTION	MATERIAL
DOUBLER A	0.032 SHEET ALCLAD 7075-T6
DOUBLER B	0.025 SHEET ALCLAD 7075-T6
FILLER C	0.040 SHEET ALCLAD 7075-T6
FILLER D	0.050 SHEET ALCLAD 7075-T6
CORE PLUG	3/16-112-4.5 NYLON PHENOLIC HONEYCOMB CORE





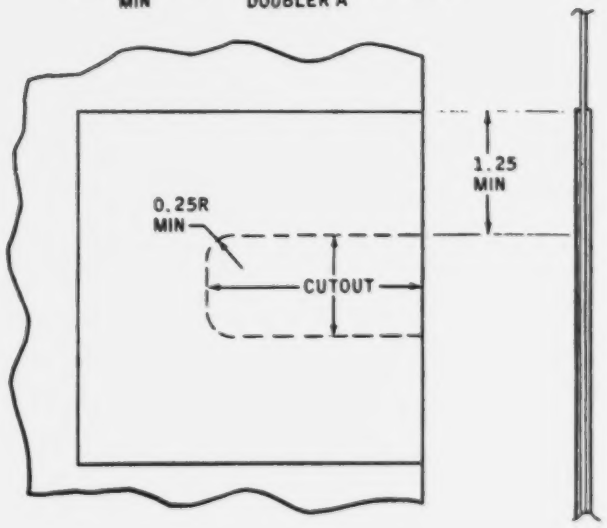
CHECKLIST

PREPARATION
1. SECURE TOOLS AND MATERIALS.
2. REMOVE PAINT.

DAMAGE REMOVAL
1. SELECT ROUTER TEMPLATES.
2. REMOVE DAMAGE, USING HAND ROUTER.

REPAIR ASSEMBLY
1. FABRICATE REPAIR DETAILS.
2. CLEAN AREA AND DETAILS.
3. APPLY ADHESIVE.
4. ASSEMBLE DETAILS, USING ADHESIVE-IMPREGNATED CHEESECLOTH AS REQUIRED.
5. CURE ADHESIVE, USING HEAT AND PRESSURE ON BOTH SIDES.
6. INSPECT REPAIR FOR EFFECTIVE BOND.

REFINISH



53-1867

Figure 3-23. Metal bonded honeycomb repair—transition area.

867

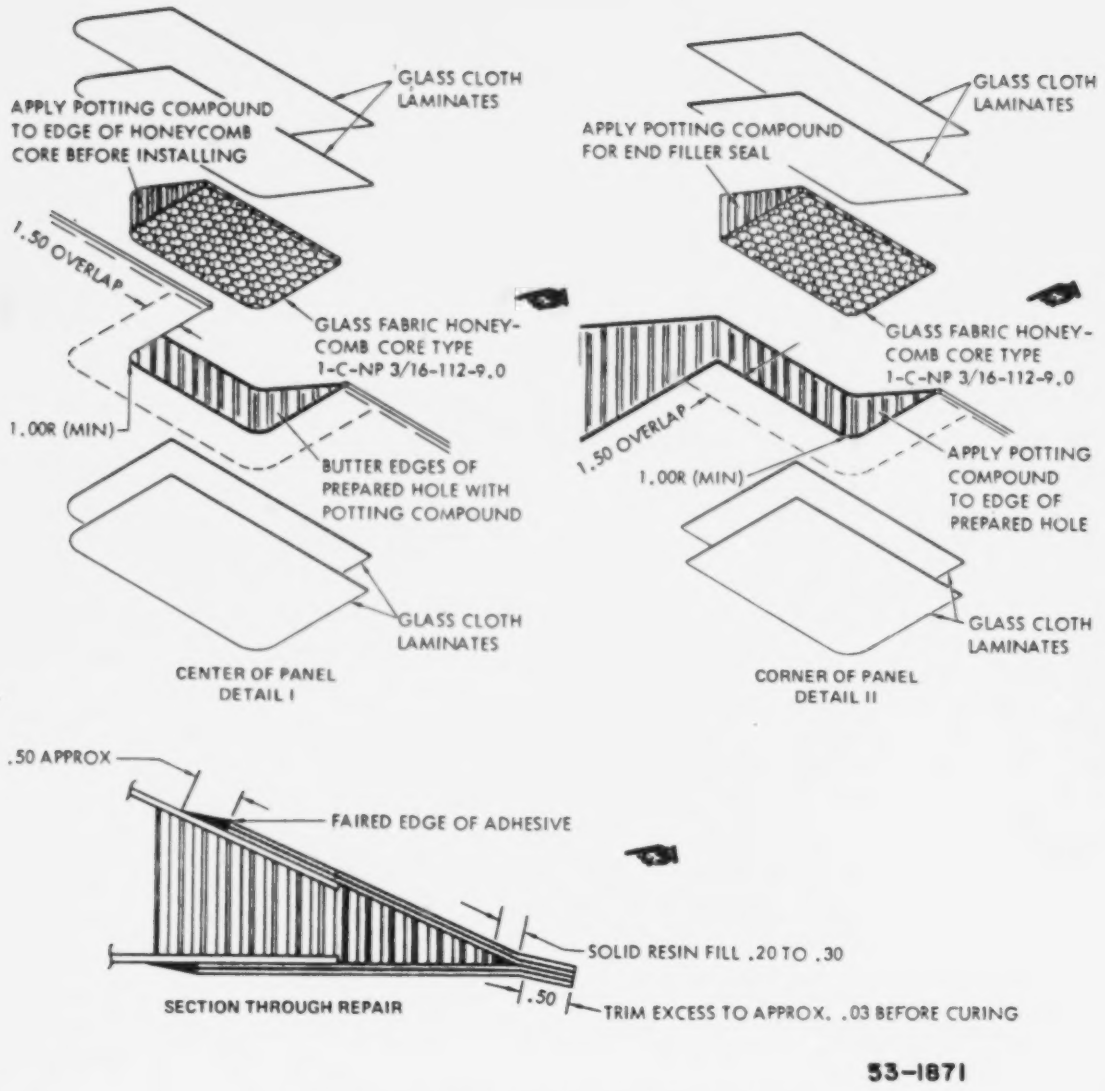

APPLY POTTING COMPOUND TO EDGE OF HONEYCOMB CORE BEFORE INSTALLING
GLASS CLOTH LAMINATES
1.50 OVERLAP
GLASS FABRIC HONEY-COMB CORE TYPE 1-C-NP 3/16-112-9.0
1.00R (MIN)
BUTTER EDGES OF PREPARED HOLE WITH POTTING COMPOUND
GLASS CLOTH LAMINATES
CENTER OF PANEL
DETAIL I
APPLY POTTING COMPOUND FOR END FILLER SEAL
GLASS CLOTH LAMINATES
GLASS FABRIC HONEY-COMB CORE TYPE 1-C-NP 3/16-112-9.0
1.50 OVERLAP
1.00R (MIN)
APPLY POTTING COMPOUND TO EDGE OF PREPARED HOLE
GLASS CLOTH LAMINATES
CORNER OF PANEL
DETAIL II
.50 APPROX
FAIRED EDGE OF ADHESIVE
SOLID RESIN FILL .20 TO .30
.50
TRIM EXCESS TO APPROX. .03 BEFORE CURING
SECTION THROUGH REPAIR
53-1871

Figure 3-24. Metal bonded honeycomb repair—trailing edge area.

bubbles. In this type of repair, the adhesive is swept out toward the edge of the repair, thus aiding in the buildup of the trailing edge area. Take care during this operation to shape the repair so that it is comparable to the original design, shape, and thickness of the honeycomb structure being repaired.

Again let us emphasize that to get a perfect adhesion of the glass cloth overlays to the repair area, all surrounding (faying) surfaces must be thoroughly cleaned until no trace of dirt, surface coating, or foreign matter appears. After the area has been completely cleaned and dried, a thin and continuous coating of adhesive primer EC-776R is applied to the faying surfaces of the repair area. The adhesive primer must be allowed to dry at room temperature, or the process may be accelerated at a recommended elevated temperature.

Exercises (860):

1. If the cutout area in figure 3-23 was originally cut-out to a size 2 inches wide and 4 inches deep, and after fabricating repair parts, additional core damage was found requiring the cutout to be enlarged to 3 inches wide and 4½ deep, indicate the effect this would have on the repair parts by showing the original sizes and the new required sizes.

   a. Doubler A _____ Original Size _____ New Size _____
   b. Doubler B _____ Original Size _____ New Size _____

2. If you had only one piece of glass cloth 22 inches square, what would the maximum size repair you could perform using the specification shown in figure 3-24, for the center panel repair?

861. Cite preparations, precautions and procedures involved in removing and replacing metal bonded honeycomb panels.

Under certain conditions, you will have to remove and replace metal bonded honeycomb panels. Some of these conditions are:

a. Damage exceeds TO specifications.

b. Addition of another repair to the panel violates TO limitations.

c. The time to replace a panel is less than the time it would take to repair the panel. In cases like this, returning the aircraft to immediate service is an important factor. The original panel is then repaired using normal processing and scheduling procedures.

d. The damage is such that the panel cannot be repaired on the aircraft properly.

Regardless of which condition dictates the removal and replacement of a metal bonded honeycomb panel, certain important work procedures must be foremost in your mind. Work procedures such as, proper removal techniques, work precautions to use to prevent damage during shop working practices, and installation techniques are the main factors to consider.

Removal Techniques. Whenever a metal bonded honeycomb panel is going to be removed, always check to see if the aircraft needs to be jacked to a jig position prior to removing the panel. And usually, if this is the case, the aircraft should not be moved or taken off jacks until the panel is replaced. Honeycomb panels are usually stress fitted when the aircraft was manufactured, and in order to be replaced, the same position or aircraft configuration used by the manufacturer during installation must be duplicated.

When removing the pane, care should be taken not to damage or elongate mounting holes on the aircraft structure. In cases where a panel is bonded on, such as the panel over the wheelwalls on the wings of the F-4 aircraft, take care *not* to scratch or scar the bonding surfaces. This will cause additional surface preparation when you replace the panel. Also, if the panel can be used to locate mounting holes and required cutouts, the panel should be removed with as little as possible removal damage. After the panel is removed, clean the mounting surface of all traces of old bonding agents and sealants. Inspect the mounting structure and plate nuts (if used) for damage.

Handling Precautions. After the panel has been removed, it should be handled with care. Work areas should be cleared of all objects that could cause additional damages. Rivet shavings, bits and pieces of removed rivets, all should be thoroughly removed from padded surfaces where honeycomb panels are to be placed. When replacement panels are received from base supply, they should be inspected for any damage incurred during shipment. In addition, every effort must be taken during the drilling and trimming of the new panel to prevent damage.

Replacement Procedures. Replacement panels come with fastener holes undrilled and a 0.200-inch trim allowance on all edges. Use hole finding methods previously covered to locate the correct locations. In many cases, holes in the new panel must be located after the panel has been trimmed and fitted to the aircraft opening. Always check TO guidelines before drilling fastener holes in a new panel in the shop area. Trim edges to fit by using a high speed router or equivalent means that will not separate the edges of the bonded panel. Drill and countersink holes to match the holes on the aircraft. When honeycomb panels are bonded in place, proper cleaning of the surface on the aircraft and the panel is a MUST to insure proper bonding.

Mounting fasteners should not be shaved after installation and head protrusion normally should not exceed 0.025 of an inch. When panels have inaccessible areas, use blind fasteners, such as Jo-Bolt or Bulbed Cherrylock rivets. The strength requirements of the panel will determine the specific type of fastener to use.

Exercises (861):

1. What preparation is indicated upon finding that a bonded honeycomb panel you must remove is stress-fitted to the aircraft?

2. Prior to bringing a honeycomb panel into the work area, what work area preparation should be made?

3. What precautions should be observed when removing a honeycomb panel from the aircraft?

4. What is the first thing you should do to a honeycomb panel just received from supply?

5. Normally, where and when should the fastener holes for a new metal bonded honeycomb panel be drilled?

CHAPTER 4

Aircraft Cables

WHEN AN AIRCRAFT has an engine failure or structural damage in midair, the pilot has a good chance of bringing the plane in safely. Failures in control cables, however, are much more serious, and the pilot had better start thinking of his parachute.

A part of your duties is the periodic inspection and repair (or replacement) or faulty control cables. Just as in the case of repairs you make on aircraft structures, all damaged control cables should be restored to their original condition—or as near the original condition as possible. Very often the job calls for a cable replacement: but, if replacements are not available, you may have to fabricate new control cables. While making such inspections and repairs, observe all safety precautions.

4-1. Features of Aircraft Cables

Aircraft cables, as you can see from the preceeding paragraphs, are a vital part of an aircraft. When repairs and replacements are needed, it is important that you select the correct type. This section is designed to give you the necessary facts you need when working with aircraft cables.

862. Specify advantages of using cable (instead of rods or tubing) assemblies in controlling aircraft systems.

Cable Uses. Cables are used on aircraft to operate and regulate control surfaces, escape hatches, life raft compartments, bomb bay doors, wheelwell doors, and engine accessories. Cables are used to tow gliders and targets; to release parachutes, bombs, and flares; to load ammunition and cargo; and to perform a number of essential maintenance functions, such as hoisting and towing.

Cables in aircraft control systems have part numbers and come prefabricated to fit from turnbuckle-to-turnbuckle or from turnbuckle-to-unit. Spar cable assemblies are not always available, so you may have to duplicate damaged ones.

Selection Factors. Many advantages are gained by the use of cables in aircraft. One of the more important advantages is that cable failure is seldom abrupt but instead is progressive over periods of extended use. They seldom break or sever even under strains such as those that occur during towing or hoisting. Cables are stronger than steel rods or tubing of the same size. They flex without setting and can easily be routed around obstacles with pulleys. Cables can be installed over long distances (a necessity in bombers) without a great degree of sagging. Vibration will not cause them to work-harden, as sometimes happens when either push-pull control rods or tubing is used.

When cables are used for the operation of a unit, they must be used in pairs—one set to move the unit one direction and the other to move it in the opposite direction. In spite of the need of a second set, weight is saved because a push rod needed to create a similar movement would be considerably heavier. Since cables are used in pairs and are stretched taut, very little play exists between the actuating device and the unit. Consequently, cable-controlled units respond quickly and accurately to cockpit control movements.

Exercise (862):

1. List six reasons why cable assemblies are used in aircraft.

863. Differentiate false from true statements related to aircraft cable assembly terms and construction features.

Cable Construction Terms. In order that you gain a fuller understanding of cable construction, the following definitions are given:

a. Wire – Each individual cylindrical steel rod or thread shall be designated as a wire.

b. Strand – Each group of wires helically twisted or laid together shall be designated as a strand.

c. Cable or wire rope – A group of strands helically twisted or laid about a central core shall be designated as a cable. The strands and the core shall act as a unit.

d. Preformed type – Cable consisting of wires and strands shaped prior to fabrication of the cable to conform to the form or curvature that they take in the finished cable shall be designated as preformed type.

e. Diameter – The diameter of cable is the diameter of the circumscribed circle.

f. Lay or twist – The helical form taken by the wires in the strand and by the strands in the cable is characterized as the lay or twist of the strand or cable respectively. In a right-hand lay (see fig. 4-1), the wires or strands are in the same direction as the thread on a right-hand screw; and for a left-hand lay, they are in the opposite direction.

g. Pitch (or length of lay) – The distance parallel to the axis of the strand or cable in which a wire or strand makes one complete turn about that axis is designated as the pitch (or length of lay) of the strands or cable.

h. Wire center – The center of all strands is an individual wire designated as a wire center.

i. Strand center – A strand center shall consist of a single, straight strand made of preformed wires, similar to the other strands comprising the cable in arrangement and number of wires.

j. Independent wire rope center (IWRC) 7 x 7 – A 7 x 7 independent wire rope center as specified herein consists of a cable or wire rope of six strands of seven wires each, twisted or laid around a strand center or core consisting of seven wires.

Control cables vary in size from 1/16 to 3/8 inch in diameter. Cables 1/16 and 3/32 inch in diameter are composed of seven strands of 7 wires each and are referred to as 7 x 7 (1 WRC) cable—that is, six strands are wrapped around the center or core strand. Figure A of figure 4-2 shows this internal feature. Also shown is the correct method of measuring the diameter of a cable. Cables 1/8 inch in diameter and larger are made up of seven strands of 19 wires each and are referred to as 7 x 19 (1WRC) cable (1 WRC stands for one wire rope center). Again, six strands are wrapped around the center strand. (See fig. B of fig. 4-2.)

Exercises (863):

In the space provided at the beginning of each statement, indicate which statements are true or false by placing the appropriate letter T or F.

_____ 1. Each group of wires helically twisted are laid together and shall be designated as a strand.

_____ 2. If the strands are twisted in a direction opposite to the twist of strands around the center or core, the cable will stretch as much as one in which all strands are twisted in the same direction.

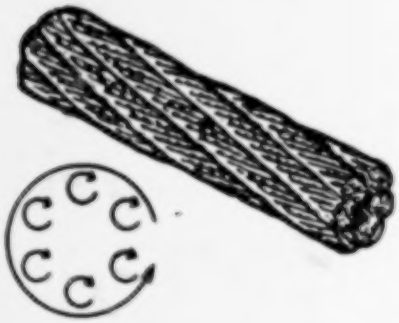
_____ 3. Preforming of cables is what helps to keep cables from spreading inside the terminals when swaging.

_____ 4. Aircraft control cables vary in size from 1/16 to 3/8 of inch in diameter.

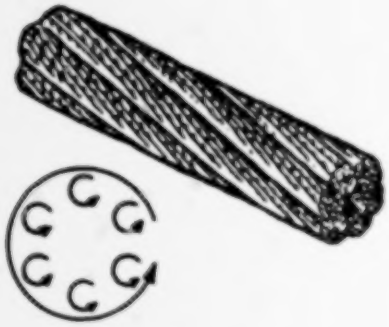
_____ 5. Cables of 1/8 of an inch in diameter and larger are made up of seven strands of 7 wires each.

_____ 6. Cables 1/16 to 3/32 of an inch in diameter are composed of seven strands of 7 wires each.

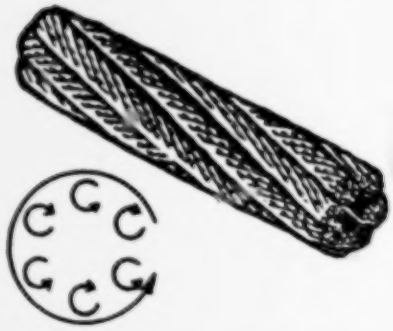
_____ 7. Reverse lay constructed cable is when the strands are twisted either to the right or to the left about the core.



RIGHT REGULAR LAY, ROPE LAY RIGHT, STRAND LAY LEFT.



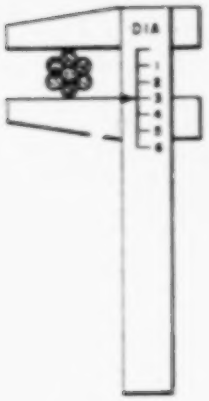
RIGHT LANG LAY, ROPE LAY RIGHT, STRAND LAY RIGHT.



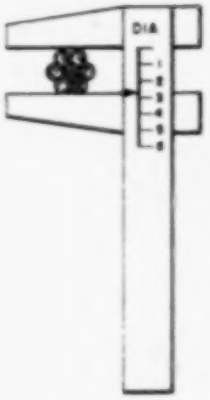
REVERSE LAY, ROPE LAY RIGHT OR LEFT, STRAND LAY ALTERNATELY RIGHT AND LEFT.

Figure 4-1. Cable lay.

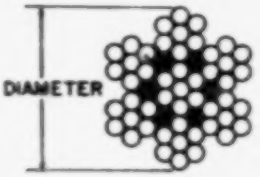
1/16" TO 3/32"
SIZE RANGE
FLEXIBLE TYPE



RIGHT



WRONG

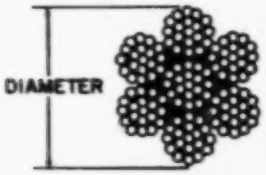


7X7

7 STRANDS - 7
WIRES TO EACH
STRAND

FIG. A

1/8" TO 3/8"
SIZE RANGE
EXTRA - FLEXIBLE TYPE



7X19

7 STRANDS-19
WIRES TO EACH
STRAND

FIG. B

53-1833

Figure 4-2. Cable sizes and measuring procedures.

_____ 8. The diameter of a cable is the diameter of each individual strand added together.

864. Distinguish between the types of aircraft cables in terms of methods of construction, fabrication materials, and substitution allowances.

Types of Cables. Aircraft cables are available in three different types of designs; flexible, nonflexible, and nylon coated cables. Each specific type has individual characteristics that you must consider when you select the most appropriate type of cable to use in a repair situation.

Flexible cables. Flexible, preformed, carbon steel cables, Military Specification MIL-C-1511, are manufactured from steel made by the acid-open-hearth, basic-open-hearth, or electric furnace process. Throughout the manufacturing operation, every precaution is taken to keep the cable made from different batches of steel separate and identifiable. The wire used in construction of the cable is coated with pure tin or zinc. Flexible, preformed, corrosion-resistant steel cables, Military Specification MIL-C-5424 and MIL-C-18375 are manufactured from steel made by the electric furnace process. These cables are of the 3 x 7, 7 x 7, 7 x 9, or 6 x 19 (IWRC) construction.

When aircraft cables are manufactured, each strand is first formed to the spiral shape to fit the position it is to occupy in the finished cable. This process is called *preforming;* cables made by such a process are said to be *preformed.* Preforming is used to obtain flexibility in the finished cables and to relieve bending and twisting stresses in the strands as they are woven into the cable. It also keeps the cable from spreading when cut. Each strand is made of highly flexible material. Some cables are so flexible that they are classified as extra flexible; others are classed as flexible. Cables as large as 5/8 inch can be obtained in the extra flexible type or as large as 1 inch in diameter in the flexible type.

Cable Construction Features. A cable is a group of wires or strands or wire twisted together to make a wire rope. The relationship of the direction of twist of each strand to another and to the cable as a whole is an important factor in its strength. If the strands are twisted in a direction opposite to the twist of strands around the center or core, the cable will not stretch or set as much as one in which all strands are twisted in the same direction.

The direction of twist (in opposite direction) is most commonly used. It is called regular or ordinary lay (refer again to fig. 4-1). Cables may have right regular lay or left regular lay. If the strands are twisted in the direction of the twist of the core, the lay is called a lang lay. There are two lang lays: right and left. Another arrangement is the twisting of all the strands either to the right or to the left about the core; this is called reverse lay.

The 3 x 7 cable consists of three strands of seven wires each. There is no core in this construction. The 3 x 7 cable has a length of lay of not more than eight times nor less than five times the nominal cable diameter. The 7 x 7 cable consists of six strands of seven wires each, laid around a center strand of seven wires. The wire is laid so as to develop a cable that has the greatest bending and wearing properties. The 7 x 7 cable has a length of lay not more than eight times nor less than six times the cable diameter. The 7 x 19 cable consists of six strands laid around a center strand in a clockwise direction. The wire composing the seven individual strands is laid around a central wire in two layers. The center core strand consists of a layer of six wires laid around the central wire in a clockwise direction and a layer of 12 wires laid around this in a clockwise direction. The six outer strands of the cable consist of a layer of six wires laid around the central wire in a counterclockwise direction and a layer of 12 wires laid around this in a counterclockwise direction. The 6 x 19 (IWRC) cable consists of six strands of 19 wires each, laid around a 7 x 7 independent wire rope center. MIL-C-18375 cable, although not as strong as MIL-C-1511 or MIL-C-5424, has non-magnetic and coefficient of thermal expansion properties superior to either, as well as, being equal to MIL-C-5424 in corrosion resistance.

The smaller corrosion-resistant steel cables are made of steel containing 17 percent chromium and 8 percent nickel. The larger cables, 5/16, 3/8, and 7/16 inch, are made of steel that contains, in addition to the chromium and nickel mentioned, not less than 1.75 percent molybdenum.

Nonflexible Cables. Nonflexible, preformed, carbon steel cables, Military Specification MIL-C-6940, are manufactured by the same processes listed for Military Specification MIL-C-1511. The wire used in construction of the cable is coated with pure zinc. Nonflexible, preformed, corrosion-resistant steel cables, Military Specification MIL-C-5693, are manufactured by the same process and have the same composition as listed for Military Specification MIL-C-5424. The nonflexible steel cables are of the 1 x 7 or 1 x 19 construction. The 1 x 7 cable consists of six wires laid around a center wire in a counterclockwise direction. The 1 x 19 cable consists of a layer of six wires laid around a center wire in a clockwise direction plus twelve wires laid around the inner strand in a counterclockwise direction.

Nylon Coated Cables. Nylon jacketed cable is made by extruding a flexible nylon coating over corrosion resistant steel (CRES) cable. The care CRES cable must conform to MIL-C-5424. Nylon coated cables are available in eight diameters from 1/32 to 1/4 inch inclusive. The 1/32 inch bare cable converts to 3/64 inch jacketed cable due to the thickness of the nylon jacket. The remaining seven diameters, up to 1/4 inch, convert to jacketed cable diameters of 3/32, 1/8, 3/16, 7/32, 1/4, 9/32 and 5/16.

The service life of jacketed cable is much greater than the service life of the same cable when used bare. Most CRES cable wear occurs at pulleys where the cable bends. The wear is caused by friction between strands and between wires. In bare cable, this is aggravated by dirt grit working its way into the cable and the lubricant working its way out, leaving dry, dirty wires to rub against each other. In long straight runs of cable, vibration work hardens the wires causing the brittle wires to fracture with eventual separation of the cable.

The nylon jacket protects the cable in a threefold manner; (1) It keeps the lubricant from oozing out and evaporating; (2) it keeps dirt grit out; and (3) it dampens the vibrations, thereby greatly reducing their effect on the cable.

Substitution Allowances. When corrosion resistant steel cable MIL-C-5424 or MIL-C-18375 is not available, carbon steel cable MIL-C-1511 may be substituted to any diameter except: where such cables are exposed to acid, strong corrosive agents, temperatures exceeding 550° F., or except where specific requirements exist for use of non-magnetic and/or high coefficient of expansion type cable material to prevent detrimental effects on adjacent or related equipment. If there is any doubt about the substitution, consult a materials engineer.

When carbon steel cable, MIL-C-1511, is not available, corrosion resistant cable, MIL-C-5424, may be substituted in the following diameters only: 1/16, 3/32, 1/2, 9/16, 5/8, 3/4. Other diameters of MIL-C-5424 will not be used as substitutes because of lack of equal strength to MIL-C-1511.

If a cable substitution is made, mark the item on the calendar inspection schedule of AFTO Form 781B, Aircraft Inspection and Maintenance Status Record. The frequency of inspection will be one-half the time of normal inspections. Characteristics of some aircraft will allow no substitution of cable; therefore, always refer to applicable maintenance manual for aircraft concerned for specific cable and tension.

Exercises (864):
After each statement write in the specific type of flexible, nonflexible, or nylon coated cable, indicated in the statement.

1. This type of cable has a strand construction design of either 1 x 7 or 1 x 19 coated with pure tin.

2. This type of cable ranges in diameter sizes from 1/32 to 1/4 of an inch.

3. This type of cable has a 7 x 7 strand construction and is manufactured by the acid-open-hearth process.

4. This type of cable has a 7 x 9 strand construction and is manufactured in an electric furnace process.

5. This type of cable has the greatest service life.

6. This type of cable may be substituted for corrosion resistant steel cable except where such cables are exposed to corrosives, high temperatures, or where requirements exist for use of non-magnetic or high coefficient of expansion type cable material.

865. Given a description of an installed aircraft cable, specify if the cable assembly should be replaced, repaired, or left in service.

In the performance of your duties as an airframe repairman, you may have to inspect cables for broken wires, worn spots, and corrosion. The results of tests show that the loss in cable strength from broken wires depends upon the concentration of breaks at any one point rather than the total number broken in the cable. Other tests have shown that cables may have broken wires and still be capable of carrying the designed load of the cable. Consult TO 1-1A-8 and the maintenance technical order for the specific aircraft about limitations as to the location and number of wires that may be broken and yet permit the cable to remain in service.

Corrosion Inspection. Corroded cables present another reason for removal and replacement of cable assemblies. Inspect the surface of cables for corrosion. If you find corrosion relieve the tension on the cable and carefully untwist the cable to visually inspect the interior. If you find more than one worn area and all are within specified limits, the cable is satisfactory, provided no two worn spots are within the same circumference. Any corrosion of the interior strands of the cable constitutes failure, and the cable must be replaced. If you detect no interior corrosion, remove loose rust and corrosion with a rag or brush moistened with solvent P-S-661b. Clean the cable with steel wool, but be careful not to damage it in the process. Coat the cable with an approved corrosion preventive material.

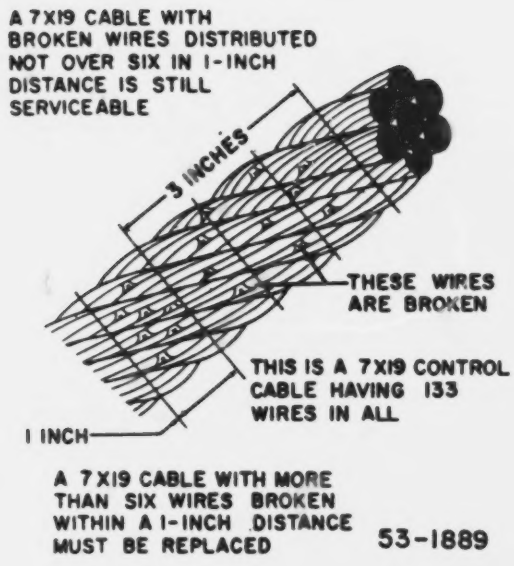

A 7X19 CABLE WITH BROKEN WIRES DISTRIBUTED NOT OVER SIX IN 1-INCH DISTANCE IS STILL SERVICEABLE
3 INCHES
THESE WIRES ARE BROKEN
THIS IS A 7X19 CONTROL CABLE HAVING 133 WIRES IN ALL
1 INCH
A 7X19 CABLE WITH MORE THAN SIX WIRES BROKEN WITHIN A 1-INCH DISTANCE MUST BE REPLACED
53-1889

Figure 4-3. Cable broken wire limitations.

Worn Cable Limitations. An inspection of cables may reveal worn spots in the strands. Any 7 x 7 cable having 3 wires or less per inch, or any 7 x 19 cable having 6 wires or less per inch, that is, not worn more than halfway through the wire diameter (provided no broken wires are present in worn area) is considered serviceable. One less worn wire per inch is allowed for each broken wire present in the same inch. Replace any cable exceeding the limits just specified.

Broken Wire Limitation. Control cables are oversize, and their load capacity may be as much as 50 percent in excess of the design loads to be sustained. Some broken wires show up soon after placing the cable in service, probably because some wires are under greater tension or are harder drawn than the rest. After these overstressed or harder drawn wires have been broken, few additional broken wires will be encountered in normal service for considerable time. As previously stated, the results of tests show that the loss in cable strength due to broken wires depends upon their concentration at any point rather than the total number broken in the cable. Tests have also shown that cables may have broken wires and still be capable of carrying the design load of the cable. At each regular inspection period, inspect cables for broken wires by passing a cloth along the length of the cable. Broken wires will snag the cloth.

Any 7 x 19 cable that has three broken wires or less per inch, per strand, provided that not more than six broken wires exist in a 1 inch running length is serviceable. Any 7 x 7 cable that has two broken wires or less per strand, per inch (provided that not more than three broken wires exist in a 1 inch length) is serviceable. The maximum number of broken wires must not occur in any 2 consecutive inches of cable, that is, if six wires are broken in 1 inch of 7 x 19 cable, or if three wires are broken in 1 inch of 7 x 7 cable, none would be allowed in the next consecutive inch of either cable. Any cable not within the above specified limits is unserviceable and must be replaced. A maximum of three broken wires per inch is allowable in the length of cables passing over pulleys, drums, or through fairleads. The critical fatigue area is the working length of the cable; therefore, when broken wires appear in this area, release the cable tension and inspect the cable closely for defects. (See fig. 4-3.)

Kinked Cable Inspection. Kinking of wire cable can be avoided if properly handled and installed. Kinking is caused by the cable taking a spiral shape as the result of unnatural twist. One of the most common causes for this twist is improper unreeling and uncoiling. Strands and wires are out of position, which creates unequal tension and brings excessive wear at this part of the rope. Even though the kink may be straightened so that the damage appears to be slight, the relative adjustment between the strands has been disturbed so that the rope cannot give maximum service and should be replaced or repaired. NOTE: Nylon jacketed cable with any cracks in the jacket shall be replaced. Usable cable life is about over when cracks begin to appear in the nylon jacket.)

Exercises (865):
Each statement contains the results of cable inspections. Indicate whether the cable should be replaced, repaired, or is left in service (okay).

1. Corrosion located on exterior strands of the cable.

2. Corrosion located on interior strands of the cable.

3. A 7 x 7 cable has 3 worn wires in a one inch area.

4. A 7 x 19 cable has 5 worn wires and two broken wires in a one inch area.

5. A 7 x 19 cable has 2 broken wires on four separate strands in a 1 inch area.

6. A 7 x 7 cable has 2 broken wires on one strand and one broken wire in a 1 inch area.

875

7. A cable has a kink in it 3 feet from the terminal.

8. Small cracks are visible in nylon jacketed cable.

866. Match the descriptions of cable hardware and accessory functions to a specific type of hardware or accessories.

Cable Hardware. The flight control system of an aircraft includes the movable surfaces that determine the direction and attitude of the aircraft, the devices by which the pilot manipulates these surfaces, and the linkage by which the movement is transmitted to the control surfaces. On many aircraft the linkage system consists of lengths of flexible cable, together with the various devices required to operate the system.

In a cable-type control system, a number of different cable hardware items are required as well as the individual sections of cable. Such items may be classified as cable fittings and cable accessory items. You need to become familiar with these accessories.

Caution must be exercised to assure that carbon steel terminals are not used with MIL-C-18375 or MIL-C-5425. Use only stainless steel terminals, however, you may use either the carbon steel or stainless steel terminals on MIL-W-1511 carbon steel cable.

Types of Cable Hardware. Cable fittings (fig. 4-4) include turnbuckles, thimbles, bushings, shackles, terminal fittings, and the items of hardware discussed in the following paragraphs.

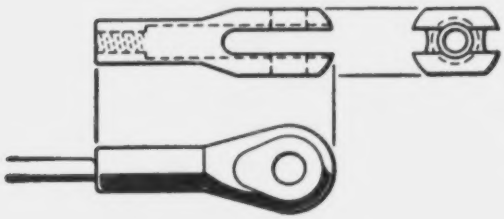
- A *ball type fitting* is a cable fitting in the form of a metal ball, drilled so it can be swaged onto a cable. A *shank* may protrude from one or from both ends so that the fitting may be swaged more securely. The ball may serve as a terminal or as a cable stop, or it may be fitted into notches on quadrants or drums to prevent creeping of the cable on the drum. Notice the single and double shank ball types shown in fig. 4-4.
- A *bushing* is a small pulleylike ring used in a cable loop. The outer surface is grooved to fit the cable, and the inner surface forms a smooth bearing. Bushings are usually made of corrosion-resistant steel. They are available in different thicknesses, diameters, depths of grooves, and sizes of hole to conform to the various sizes of the cables with which they are to be used.
- A cable *eye* is an end or terminal fitting for connecting a cable to another fitting. It may form the end of a swaged fitting. A cable bushing can be considered an eye.
- A *fork* is a terminal fitting that has two prongs to fit over the mating prong of an eye. Notice rod end terminal in fig. 4-4.
- A *shackle* is a metal loop by which cables may be attached to a unit. A shackle is usually used in connection with a loop and thimble.
- A *thimble* is a pear-shaped grooved loop of thin metal around which a cable is bent for splicing. Thimbles reinforce cables and prevent chafting and sharp bending at points of attachment. Thimbles can be obtained in various sizes to accommodate various sized cables.
- A *turnbuckle* is a device (shown at bottom of fig. 4-4) for joining cable ends and for adjusting cable tension. A turnbuckle assembly consists of a barrel and two connecting fittings, either forked, eye-shaped, or sleeved. The barrel is fitted with left- and right-hand threads at opposite ends; the turning of the barrel will cause both fittings to move in or out simultaneously, the cable thus being either tightened or loosened.

Types of Cable Accessories. Various cable hardware items serve as acessories to the function of the individual cables. Some transmit motion, increase or decrease cable travel distance, prevent slippage, reduce vibration in long distances of cable, and change direction of the cables. The following paragraphs explain these accessory items.

- An *actuator* is a device that sets something else in motion. In cable control systems it is a casting to which cables are attached. Cable quadrants and drums located in the pilot's pedestal are actuators, since motion is transmitted to the cables by them.
- A *bellcrank* is used chiefly for changing cable direction or for increasing or decreasing cable travel distance. A bellcrank may often be placed at the end of a cable to serve as an actuator of a unit.
- A *cable drum* is a cylindrical casting with several grooves about which a cable can be wound so there will be no cable slippage. Drums are placed at points where a very slow and sure motion is desired. The adjustment mechanism for trimming of tabs is a good example of the use of a cable drum.
- A *fair-lead* is a small fixture, usually made of plastic material with one or several holes through which cables may pass. It is used to prevent cables from coming in contact with structural parts of the aircraft and to reduce vibration in long stretches of cable. Whenever cables pass through pressurized compartments, fair-leads must be airtight. In such instances pressure seals are used as fair-leads.
- A *pulley* is a grooved wheel, often made of plastic material, which supplies a rolling bearing at a point where the cable changes direction.
- A *quadrant* is a casting to which cables are attached for actuating purposes. It is usually a fractional part of an actuating pulley (consequently, the term quadrant). The quadrant is actuated by an attached lever, and this action transmits motion through the cable to a drum or an actuating pulley, which in turn causes movement in the unit.

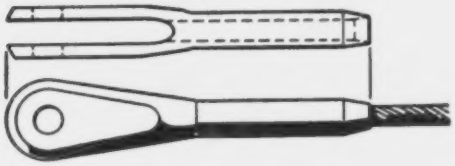
DOUBLE SHANK BALL END TERMINAL

SINGLE SHANK BALL END TERMINAL

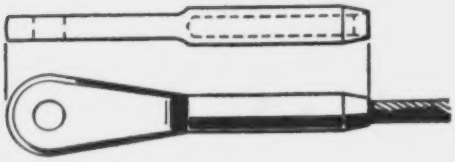


ROD END TERMINAL

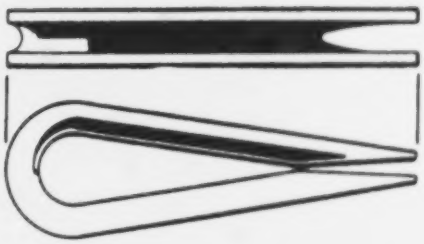
THREADED CABLE TERMINAL



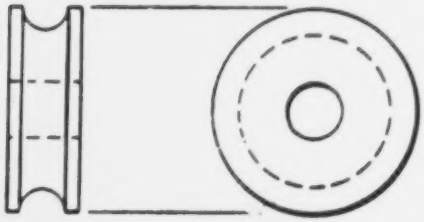
FORK END CABLE TERMINAL



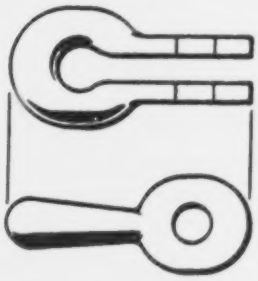
EYE END CABLE TERMINAL



WIRE CABLE THIMBLE



CABLE BUSHING



CABLE SHACKLE

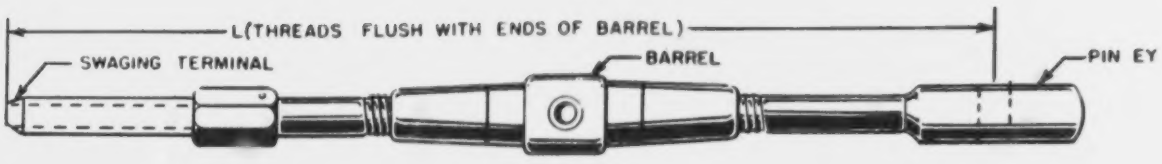


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Figure 4-4. Cable hardware.

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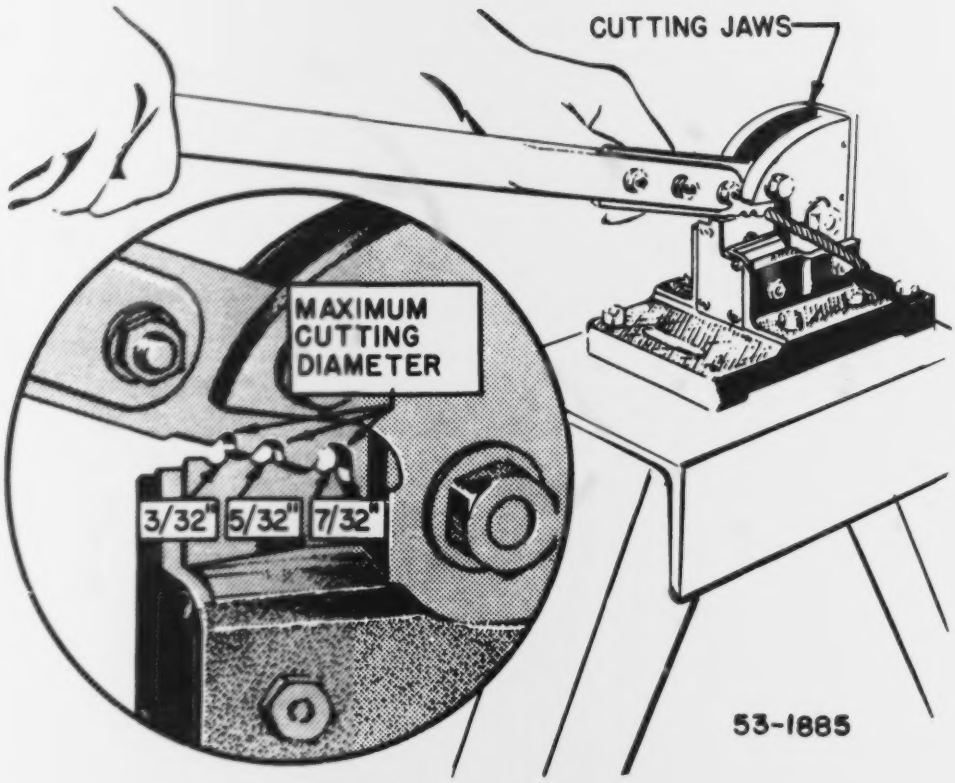

Figure 4-5. Cable cutting machine.

• A *sheave* is a large pulley, usually made of metal, which performs functions similar to those of bellcranks (that is, reducing or increasing travel distance and changing direction of cables).

Exercises (866):
Match the specific item of cable hardware and accessories given in column 2, with a specific statement given in column 1, by placing the letter of the cable hardware or accessories listed in column 2 in the space provided in column 1.

Column 1	*Column 2*
___ 1. A metal loop by which cables may be attached to a unit.	a. thimble
___ 2. Used to change cable direction.	b. ball terminal
___ 3. Mating terminal for eye terminal.	c. Fork terminal
___ 4. Prevents chafing at cables at points of attachment.	d. shackle
___ 5. May be used as a cable stop.	e. turnbuckle
___ 6. Used to reduce vibration in long stretches of cables.	f. bushing
___ 7. Function similar to those of a bellcrank.	g. bellcrank
___ 8. Used to adjust cable tension.	h. actuator
___ 9. Used with cable and loop.	i. sheave
___ 10. Set cable assemblies in motion.	j. fair-lead

1-2. Fabrication of Cable Assemblies

When cable assemblies are not available as needed replacement items, they will have to be fabricated. Should immediate replacement be required, certain alternate cable fittings and processes may be substituted for the original items. Replacements for swaged cables may be prepared by using cable bushings and eye splices and the proper combination of

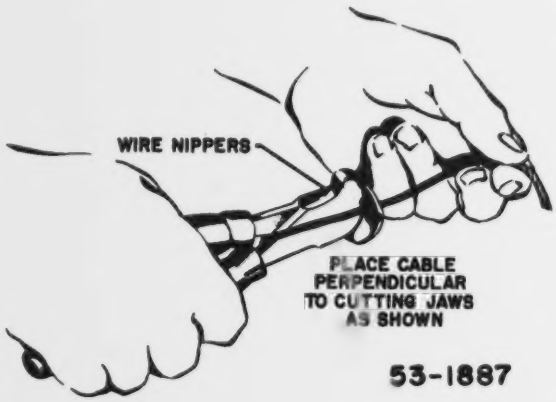

Figure 4-6. Cable cutting—wire nippers.

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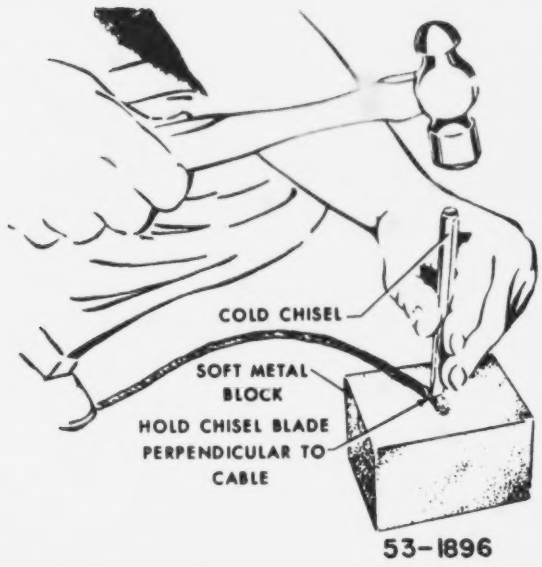

Figure 4-7. Cable cutting—cold chisel.

turnbuckles and clevises. Eye-type swaged terminals may be replaced by a cable bushing in an eye splice. Clevis-type terminals may be replaced by cable thimbles in conjunction with an eye splice and a shackle. Whenever selecting hardware for cable assemblies, be sure to follow technical order recommendations.

867. Given a work situations related to fabricating aircraft cable assemblies, specify the recommended work procedure.

Cable Cutting. Cables may be cut by any cutting method except a torch. When cutting cable, you must try to make a sharp square cut without greatly disturbing the strand group. The cable cutting machine (shown in fig. 4-5) is used primarily for cutting 3/32-, 5/32-, and 7/32-inch cables. Larger cables should be cut with a radiac (a thin abrasive wheel that revolves at high speed).

Smaller cables can be cut satisfactorily with wire nippers, heavy-duty diagonal cutters, or with side cutters, as shown in figure 4-6. There is the possibility of a cable unraveling or fraying when it is cut. To avoid this, wrap a strip of masking or friction tape around the cable so that when it is cut, half of the taped width will remain on each end of the cut cable. The tape aids in making a clean cut. A cold chisel, as shown in figure 4-7, properly used in conjunction with a soft metal block, will usually give satisfactory results when you are cutting cable.

Cable Swaging. When applied properly, the swaged terminal forms a bond stronger than the cable. This factor, along with the compactness and ease of manufacture and repair, accounts for the wide acceptance of this fitting by the aircraft industry and the Air Force. The terminals are manufactured in sizes to fit the various size cable used on aircraft; furthermore, a terminal cannot be effectively used for any size cable except that for which it is manufactured.

The terminals are attached to the cable by a forming or cold-working process that reduces the sleeve diameter of the terminal. This cold working with a swaging machine presses the terminal sleeve with sufficient pressure to force the metal to form around the wires of the cable. This operation requires a tremendous force at the point of application.

The pressure exerted by the dies rolls out the metal similar to a rolling pin rolling out dough. Since cables are manufactured with the terminal connectors to fit at specific distances, you must consider this elongation of the terminal when attaching the fitting; otherwise, the cable will not be of the correct length when finished.

Always use swaged terminals if at all possible. When swaging a terminal, cut the cable to the required length (allow for the fitting elongation). Before inserting the cable end into the terminal for swaging, be sure that the cable has been cut square and clean, and that all strands remain in a compact group. Dip the cable end into some light oil, such as number 10 SAE, and then insert the lubricated end into the terminal to a depth of approximately one-half of the barrel's length.

Bend the cable toward the terminal to about a 45° angle; then, straighten the cable back to normal, and push it the remaining distance into the terminal barrel. Kinking the cable in this manner provides enough friction to hold the terminal in place until the swaging operation can be performed. Bending the cable also tends to separate the strands inside the barrel and reduces the strain placed on them by swaging.

When swaging terminals, install the proper size dies in the swaging machine or hand swager for the size of the terminal being used. Insert the cable end and terminal into the swaging machine and perform the swaging operation. After swaging is completed, measure the outside diameter of the terminal barrel to determine if it has been swaged sufficiently. If the terminal is bent more than the allowable 1/2°, place it securely in a vise and straighten it with a mallet or with moderate pressure from the jaws of the vise.

If swaged terminals are to be used on each end of the cable, both ends of the cable must be swaged. Be sure that all additional fittings and accessories, such as cable stops and fair-leads, are slipped onto the cable first and in the proper sequence before swaging the other end.

Repair Procedure. When a cable is completely severed, or so badly damaged in one place that the strength is obviously below the minimum allowable, it may be repaired by the use of a swaged-type male eye terminal AN 668 or MS20668 bolted to a swaged-type

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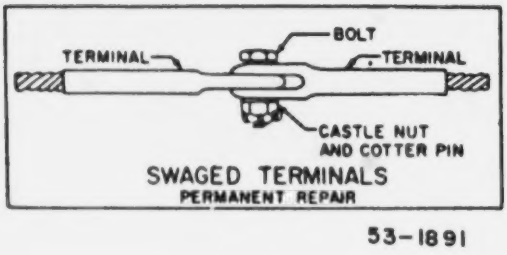

Figure 4-8. Cable repair.

female fork terminal AN 667 or MS20667, as shown in figure 4-8. Use a turnbuckle if adjustment is necessary. However, either assembly can be used only in lengths of cable that do not pass over pulleys or through fairleads.

Exercises (867):

1. When a cable cutting machine is not available, how can small cable be cut?

2. When a cable cutting machine is available, what is the largest cable that can be cut?

3. To prevent cable ends from slipping out of terminals during swaging, what must you do?

4. If a terminal after swaging is bent more than the allowable 1/2°, what action can you take?

5. Besides measuring the length of the cable wire, what else must be considered when determining overall length of a cable assembly?

6. To prevent the cable from unraveling when cut, what should you do, and how should you make the cut?

868. Given the procedures already followed in swaging a specific type of cable hardware (using a Kearney swaging machine), specify the next appropriate work procedure in the sequence.

Kearney Swaging Machine. This machine (fig. 4-9) comes in a case and has interchangeable dies or rollers. It can be assembled to swage terminals on all cable sizes up to 1/4 inch that are commonly used in aircraft.

A set of dies consists of two rollers, and each set is clearly marked for a specific cable size. When swaging terminals with this machine, be very careful to check the size of the cable, terminal, and dies to make sure they are of identical size. Incorrect sizes cause an improper and unsatisfactory bond, and possible damage to the machine.

Machine set-up procedures. Always select swaging rolls and guide sockets to fit the work to be done. Cable sizes stamped on each one. Rolls for shank-type terminals have one cutaway segment, while rolls for ball-type work have four. The roll with the two extended pins on its face is the lower roll; and plain one is the upper roll. The rolls must be installed with the lettered face showing.

Swaging operation (straight-shank terminals). After the rolls have been properly located on the shafts, secure them with the roll washers and cap screws provided, (see fig. 4-10). Do not force the rolls on the shafts. When the keys are properly positioned, the rolls will slide on their shafts readily. Next, grasp the two pins on the lower roll and rotate the rolls to their approximate starting positions, leaving room between the rolls for insertion of the terminal.

If not already in place, install the proper size feed guide adapter in the guide assembly, as shown in figure 4-11. The two feed guide adapters are marked for proper cable sizes. It is important that you use the proper feed guide adapter since this will assist in positioning the terminal at the proper point for starting the swaging operation.

Once the machine is set-up, insert the cable into the terminal so that it will be tight when fully inserted. Insert the terminal against the conical end of the feed guide adapter and press the cable into the spring clip on the guide assembly as shown in figure 4-11. Slide the guide assembly with terminal in proper position, until the terminal is located in swaging position between the two rolls. Move the guide assembly all the way toward the right, when facing the swager. While holding the guide assembly, rotate the rolls by gaping the two pins in the lower roll, until the rolls are tight against the terminal.

Operate the handles of the swager in a ratcheting manner until the rolls have passed completely over the terminal sleeve. When the first pass has been completed, a longitudinal fin or flash on two diametrically opposite sides will be noticeable on the swaged portion of the sleeve, (see part A of fig. 4-12). To eliminate the longitudinal fin, rotate the terminal 90° from the first position and pass it through the rolls as outlined earlier. After the second pass, the terminal shank will appear smooth and round, as shown in part B of figure 4-12.

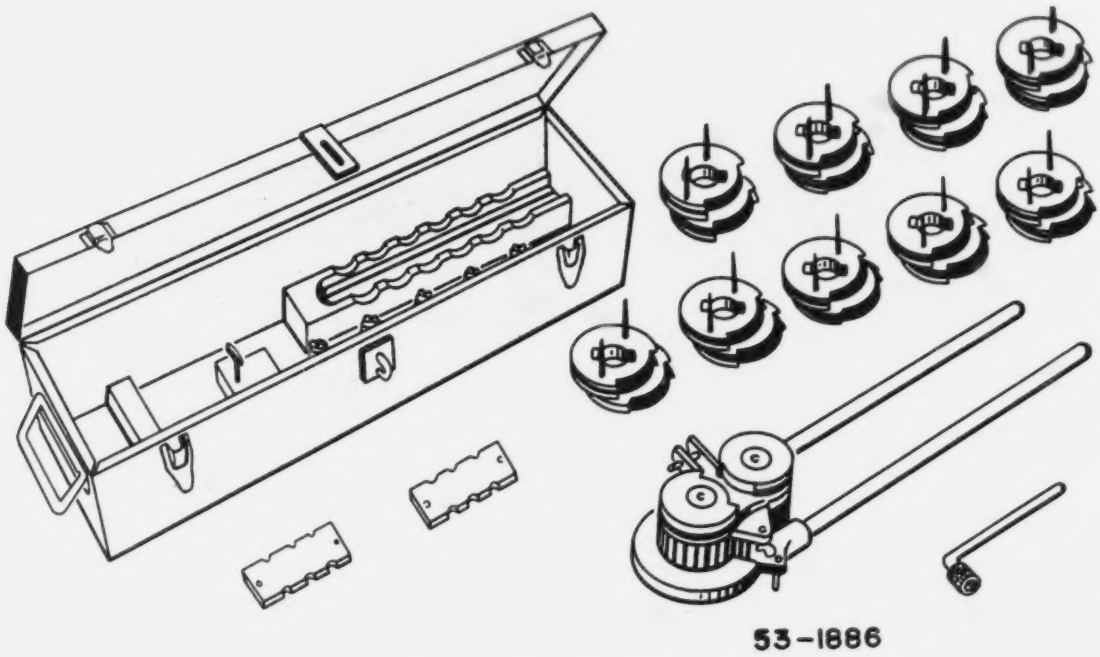

Figure 4-9. Kearney cable swaging machine.

Swaging operation (shank-type ball terminal). When it is necessary to swage shank-type ball terminals, following these procedures:

a. Select the single shank-type ball terminal to fit the size of cable being used.

b. Install the correct size shank-type ball terminal roll assembly on the swager in the same manner as described for the straight-shank terminal roll assemblies.

c. With the shank-type ball terminal properly located on the cable, use the two pins on the lower roll to rotate the rolls until the ball has just started to enter the socket at the No. 1 position, as illustrated in figure 4-13.

d. Before operating the handles to pass the terminal through the No. 1 position on the rolls, be sure that the terminal is properly positioned with the shank sleeve pointed toward the right (fig. 4-13).

e. Roll the ball through the No. 1 position on the rolls slowly to compress the terminal on the cable. Make certain that the ball enters the socket accurately in order to prevent distortion of the ball.

f. To remove the ridge left by the first pass, rotate the terminal 90° from the first position and reposition the rolls so that the terminal ball is just ready to enter the ball socket No. 2. Roll through the No. 2 position.

g. Repeat the same procedures at the No. 3 and No. 4 position on the rolls. Rotate the cable and terminal 45° before making the third pass, and 90° before making the fourth pass.

Troubleshooting. If the preceding instructions are followed, no trouble should be encountered in producing swaged terminals that pass all of the characteristics required by aeronautical standards. If results are improper, the swager is either being used incorrectly, or non-standard cables or terminals are being used. Following is a list of possible troubles and probable causes.

	TROUBLE	PROBABLE CAUSE
a.	TERMINAL SHANKS ARE NOT ROUND AFTER SWAGING.	1. Swaging with unmatched rolls. 2. Swaging with damaged rolls.

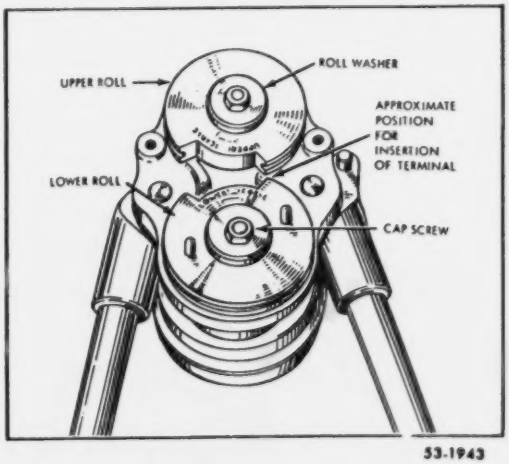

Figure 4-10. Rolls installed on swaging machine.

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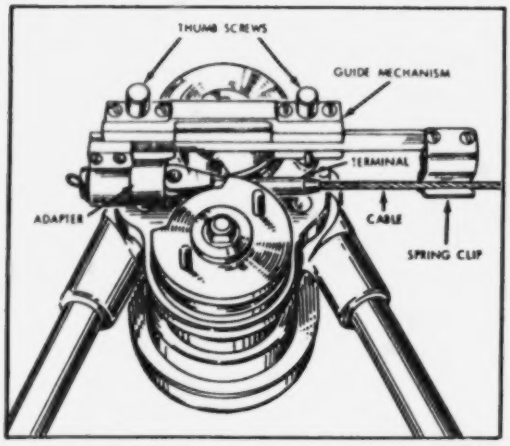
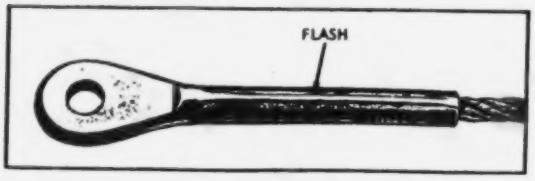
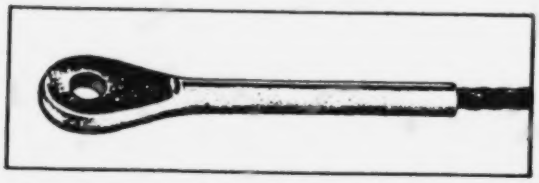


Figure 4-11. Starting positions of swaging operation.

b.	TERMINAL SHANKS NOT SUFFICIENTLY REDUCED IN SIZE.	1. Use of improper size rolls. 2. Damaged front plate. 3. Damaged bearings in the swaging machine allowing rolls to separate.
c.	TERMINAL SHANKS BEND DURING SWAGING.	1. Swaging with unmatched rolls. 2. Failure to use guide assembly.
d.	BALL-TYPE TERMINALS NOT ROUND AFTER SWAGING.	1. Balls not being properly fed into roll recesses. 2. Swaging with unmatched rolls. 3. Upper roll installed upside down.



A. *Flash Left on Terminal Shank After First Pass*



B. *Terminal that Has Been Properly Swaged*

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Figure 4-12. Terminal swaging results.

Inspection Guidelines. When swaging is completed for a terminal sleeve fitting, measure the diameter of the terminal sleeve with the gage. (See fig. 4-14.) The sleeve should now slide through the slot from one end of the swaged portion to the other except for the slight "flash" left after the second pass. The diameter over "flash" should not exceed the shank diameter after swaging by more than 0.010 inch. The gage is made to pass a terminal which has been reduced to the proper diameter as specified in applicable AN drawings except over "flash." If the terminal has not been sufficiently reduced, an additional pass may be necessary

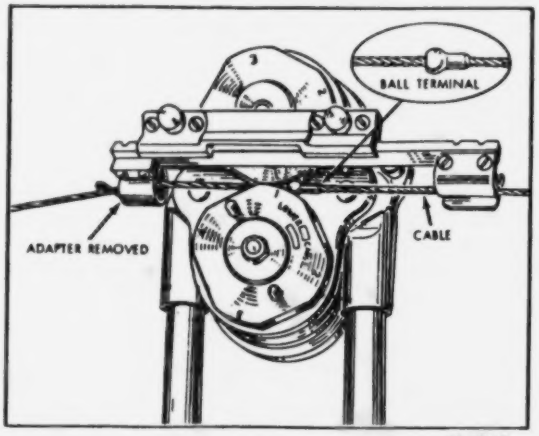

Figure 4-13. Swaging single-shank ball-type terminals.

to reduce it to the required diameter. (CAUTION: Over-swaging causes work hardening, or leads to embrittlement that can induce terminal cracking. For this reason, never use more than four passes. If four passes are required on any job, and after the fourth pass the diameter of the sleeve has not been reduced to the proper size, survey the equipment and recheck operation steps in order to determine what is causing the trouble.)

For ball-type terminals, the gage shown in figure 4-15 is used to check the terminal before and after the swaging operation. The ball terminal gage is designed to measure the diameter of the shank and ball between "flash" after swaging. Remember that the large circular openings on the "BALL" side of the gage are for measuring the balls *before* swaging, and the slots are for measuring the balls *after* swaging. (See fig. 4-15.)

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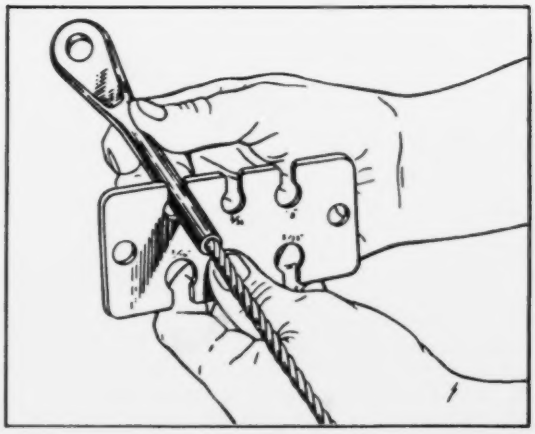

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Figure 4-14. Gaging terminal shank after swaging.

On the opposite side of the gage marked "SLEEVES," the large diameter openings are for measuring the sleeves *before* swaging and the slots are for measuring the sleeves *after* swaging.

Exercises (868):

1. After the rolls have been mounted and aligned for swaging a straight-shank terminal, what is the next step in the setting up the Kearney swaging machine?

2. After the first pass is made through the rolls when swaging a straight-shank terminal, what is the next step to follow?

3. After the correct size rolls have been mounted for swaging shank-type ball terminals, what is the next step to follow?

4. After completing two positions on the rolls used to swage shank-type ball terminals, what procedure is used for the No. 3 position on the rolls?

5. If it takes more than four passes to reduce a terminal sleeve to proper diameter, what should you do?

869. Specify procedures for swaging cable terminals using a pneumatic cable swager.

Description. This lightweight swager, figure 4-16, is a hand-held or bench-mounted machine for effectively swaging aircraft and other terminals onto cables, in sizes from 1/6 of an inch to 1/4 of an inch. The swager comes equipped with pairs of swaging dies to swage the following terminals:

a. Ball end, single shank, MS20664 (AN 664) sizes - 1/8", 1/16", 3/32", 5/32", 3/16".

b. Ball end, double shank, MS20663 (AN 663) sizes - 1/16", 3/32", 1/8", 5/32", 3/16".

c. Sleeve terminal dies used on MS21259 (AN 666) stud end, MS20667 (AN 667) fork end, MS20668 (AN 668) eye end, MS21260 (AN 669) stud end, sizes 1/16 of an inch to 1/4 of an inch.

The swager also comes equipped with matching pairs of cutting dies to cut off cable in sizes from 1/16 to 1/4 of an inch. For gaging terminals after swaging, a leaf type "Go Gage" is supplied. In addition, a foot valve with a built-in lubricator and airline hose are supplied, all nested in an appropriately partitioned metal carrying case.

The swager cold flows (cold forming) the terminal material into the strands of the cable, with the outside diameter of the swaged terminal controlled by the dimensions and forms of the swaging dies, which are used in pairs. The outside diameters of the terminals must conform to the "go" dimensions of the leaf gage supplied.

Operating Precautions. The following precautions must be observed when using this swager:

a. Before depressing foot valve, make sure dies are properly seated against terminal. This is done by bringing the rear die forward manually with the index finger against the terminal and thereby, in contact with the front die.

b. Make sure that air supply is shut off before changing dies, as accidental actuation of foot valve may result in damage to swager or injury to personnel who may be changing dies.

c. Do not operate swager until both dies are in swaging position.

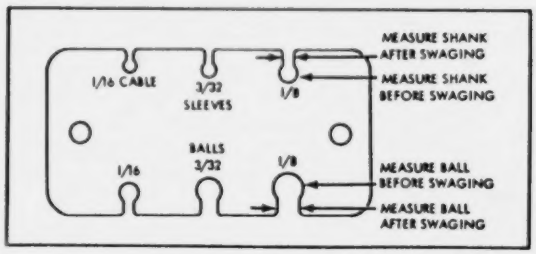

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Figure 4-15. Ball terminal gage.

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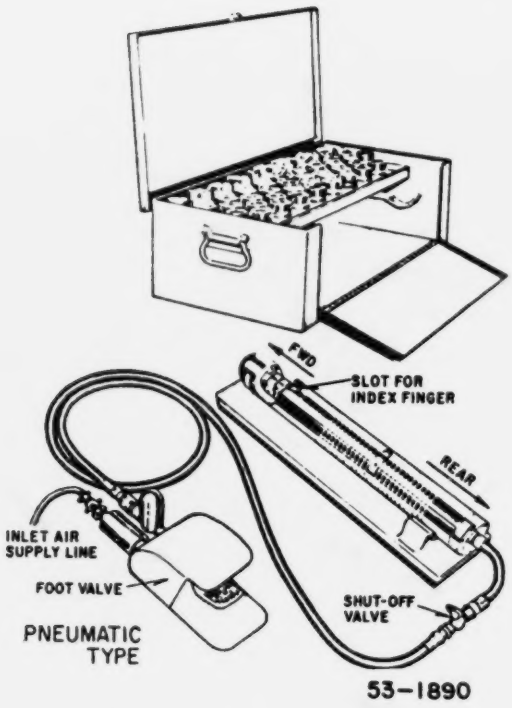


Figure 4-16. Pneumatic cable swager.

d. Keep fingers and hands away from die swaging area at all times when air supply is connected to swager.

e. During swaging, to prevent damage to the terminal or cable, maintain a light pressure on the cable towards the front of the swager, holding terminal and cable firmly in the die cavity.

f. Make sure the lubricator is filled before starting swaging.

g. Always use a safety guard when swaging. This is designed to prevent accidental injury, afford maximum protection, and provide no operational interference. NEVER place your hand in die chamber.

Swaging Procedures (Ball-End Terminals). Set-up procedures are done with the air supply shut off. The matched pair of swaged dies are lightly oiled before insertion. The rear die is inserted by sliding the die in on the keyway, with the die swaging face positioned toward the nose of the swager; slide back in bore against stop. The front die is positioned with the die swaging face pointing away from the nose of the swager, so that now both die faces are toward each other and in line, each positioned to receive half of the terminal. When this is completed, slide the rear die forward with index finder, engaging terminal and cable to the ready position.

When hand swaging, hold swager in your left hand, being careful to keep your fingers away from swaging area; hold terminal and cable in your right hand. When bench swaging, position the swager onto the holding "bench cradle" with the swager nose facing operator. The swager is positioned onto the pin in the bench cradle, which engages hole in bottom of swager. The back of the swager rests on the curved seat near the back of the holding cradle.

The swaging procedures are as follows:

a. Push cable into ball end terminal, allowing 1 to 1½ inches to extend beyond the end of the ball. Cable may be slightly "kinked" to provide stops in front and rear of the terminal ends. This prevents movement of the terminal during swaging operation.

b. Clean terminal and apply a drop of light machine oil to the swaging surface.

c. Using both hands (bench swaging) hold the terminal-cable assembly about 1 inch from either side of the cavity of the front (NOSE) die, and, with index finger, slide the rear die to forward position against the terminal, using the annular groove in the rear die as an index finger leverage groove. Keep light pressure on the terminal and cable in "nose die" cavity towards the nose.

d. Depress the foot valve with right foot, as you would depress the accelerator on a car, gradually increasing pressure until fully depressed. At the same time, rotate the cable radially back and forth about a half a circle at a time or continued all the way around.

e. Release foot valve to stop swaging operation. Remove swaged terminal and cable from swaging tool and check both ball and shank diameter with gages provided. If diameters are still too large, or if the sleeve is too rough, repeat steps a through e, changing swaging time experimentally.

Swaging Procedures (Sleeve Type Terminals). When swaging sleeve type terminal fittings, push the cable into sleeve terminal allowing the cable to protrude by 1/4 of an inch if the hole in the terminal is drilled completely through the terminal. To prevent the terminal from sliding out, push the cable about half way in and then "kink" the cable slightly and push it in all the way. This "kink" will serve as a friction lock inside the terminal. When inserting terminal into swager, hold the threaded or forked end of the terminal and insert terminal into die cavity until the shank end is approximately 3/4 of an inch into the mouth of the die. Then the rear die is slid forward with the index finger.

During the swaging operation, rotate the terminal continually, either in half circles or full circles depending upon whether the length of the cable allows complete revolutions, which are preferred. At the same time, feed the terminal slowly through the dies. When the full length of the terminal has been swaged, continue swaging, reversing the direction of in and out feed through the die until the starting position has been reached. Repeat this motion, including the revolving of the terminal, until swaging is complete.

Exercises (869):

1. Before operating the pneumatic swager, where should the rear die be positioned?

2. During the swaging operation, what procedures are recommended to prevent damage to the terminal or the cable?

3. Before dies are inserted into the swager, what must be done?

4. How should the swager be positioned during table swaging?

5. How should the cable be held during the swaging operation used for ball-end terminals?

6. What must be remembered when setting-up the pneumatic swager?

7. What must be used each time you operate the pneumatic swager?

8. How far into the swaging dies should you position a sleeve type terminal at the start of the swaging operation?

9. When swaging a sleeve type terminal using the pneumatic swager, what is also done as the sleeve is rotated during the swaging process?

10. Besides swaging terminals to cables, what other operation can be accomplished with the pneumatic swager?

870. Specify equipment and procedures used to test locally fabricated cable assemblies.

Testing Fabricated Cables. All locally fabricated, reworked, and repaired cable assemblies must be tested for proper strength before installation. The desired method is to simulate the installation arrangement including pulleys where required (if such simulation is not possible a straight pull test may be made). Apply a test load of 60 percent of the minimum allowable breaking strength gradually to one end of the cable and with the other end securely anchored. Hold the cable under tension for 3 minutes; release and examine it for damage, and the fitting for any sign of failure of attachment. Refabricate all cables that do not pass the test. A suitable guard should be placed over the cable while it is being tested to prevent injury to personnel or damage to equipment, should the cable break.

Swaged Terminal Pull Tester. The cable terminal tester, shown in figure 4-17, is a self-contained, hydraulic unit in which the tensile load applied to the test cable and terminal assembly is produced by developing pressure in a hydraulic work cylinder. The pressure in the work cylinder is related to the pounds tensile applied to the terminal and cable assembly and is indicated by a direct reading pressure gage calibrated in pounds tension. The face of the gage is graduated and indicated by cable size and the respective 60 percent rated tensile strength. The unit is light and small enough to be easily carried by one man. This compact size adds to its versatility because it can be used in small areas, which means that swaged fittings can be proof-loaded after the cable has been installed in the airplane.

The range of cable sizes and terminal types that can be tested with this unit is sufficient to cover more than 90 percent of the aircraft type terminals now being used. During the testing, the cable is held between two soft copper blocks. The unit is simple and no experience or training is required to effectively test terminal and cable assemblies. Avoid overloading small diameter cables.

To operate this cable swage pull tester, follow these simple procedures: (Refer to fig. 4-17.)

a. Determine the size and type of cable and terminal to be tested.

b. Prepare the tester by turning the tension adjusting screw (5), vise screws (1) and adjusting screw (9) counterclockwise as far as possible (numbers refer to those shown in fig. 4-17).

c. Select the proper pair of vise jaws (6) and terminal adapter.

d. Insert terminal adapter into hool (3). If a threaded type terminal is to be tested, screw the terminal into the adapter before inserting adapter into hook.

e. Insert either of the two vise jaws into the vise (7) opening with the flange to the left and copper insert facing up.

f. Slip cable through opening in vise and lay it into groove in lower vise jaw.

g. Place upper jaw over cable and lower jaw.

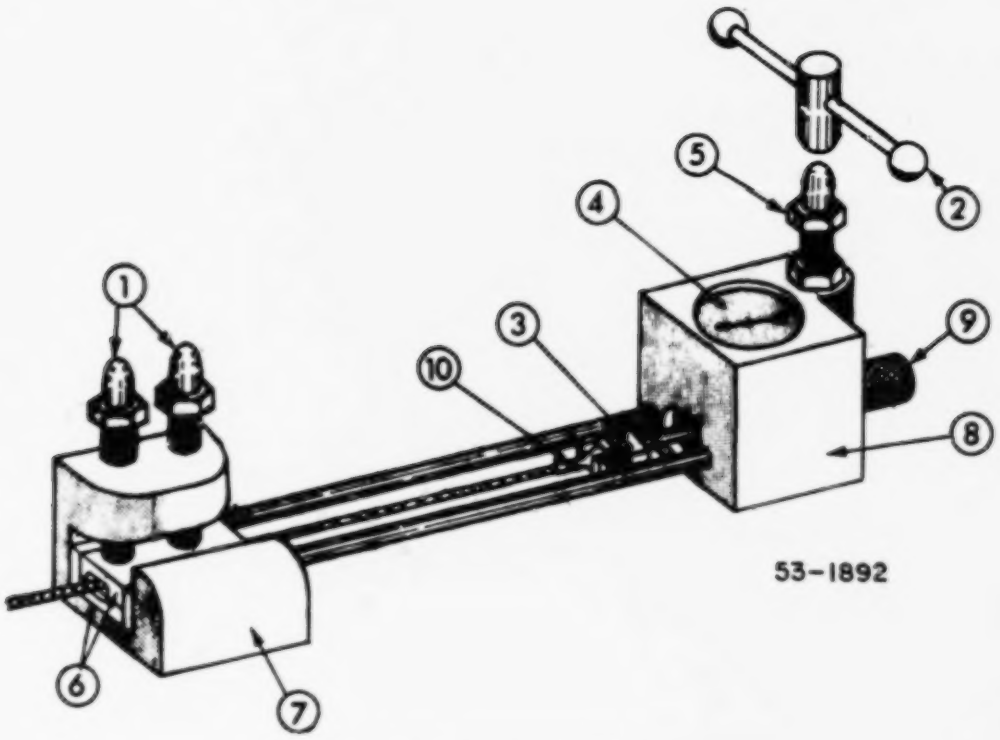


Figure 4-17. Swaged terminal pull tester.

h. Pull cable through the vise jaw, remove slack and center the cable in groove of vise jaws.

i. Push jaws toward loading head (8) until they shoulder against the vise.

j. Turn vise screws clockwise to tighten vise jaws on the cable. CAUTION: The vise jaws must be tightened down securely to eliminate the possibility of the cable slipping during test.

k. If slipping occurs on larger sizes of cables, a cinch block may be used. When using a cinch block, it is positioned in the center of the rod on tester. Wrap the cable around the cinch block once, before performing step *f*. The cinch block will align itself by pulling the cable tight using the setscrews. Then continue with steps *g*, *h*, *i*, and *j*.

l. Turn the adjusting screw (9) until some deflection is mated in the gage.

m. Turn tension adjusting screw clockwise until the desired load is attained as indicated on the tension gage (4).

After the cable and terminal assembly has been tested, remove as follows:

a. Turn tension adjusting screw (5) counterclockwise as far as possible.

b. Turn adjusting screw (9) counterclockwise as far as possible.

c. Turn vise screws (1) counterclockwise as far as possible.

d. Remove terminal adapter from hook.

e. Pull cable and vise jaws out of vise and remove vise jaws from cable. The tester is then ready to start another testing operation.

Exercises (870):

1. How much and for how long is the pressure applied to a repaired or locally fabricated cable assembly?

2. What is used to hold the cable during testing?

3. What must you avoid when using the swage terminal pull tester?

4. What is the purpose of the two soft copper blocks used with the swaged terminal pull tester?

5. When would you use a cinch block when using a swage terminal pull tester?

Aircraft Tubing

MODERN DAY AIRCRAFT have hundreds of feet of tubing running throughout the wings and fuselage. You are not responsible for maintaining the fluid systems, but in many instances you will be called upon to repair and fabricate sections of tubings. Therefore, a knowledge of the material, tools, and equipment used in repairing and fabricating new tubing assemblies is necessary.

5-1. Aircraft Tubing Assemblies

Tubing assemblies installed on aircraft are either made of metal tubing and fittings or of flexible hose. Metal tubing and fittings are used in high-pressure or critical systems, while flexible lines are generally used in low-pressure systems for attachment of units which are subjected to vibration. As an Airframe Repairman, the metal tubing and fittings are your areas of responsibilities. With this in mind, this is the direction our discussion will follow.

871. Select the appropriate type tubing to use in given repair situations.

Generally, all copper tubing has been replaced with aluminum alloy or corrosion-resistant steel tubing. The high fatigue factor of copper tubing is the chief reason for its replacement. It becomes hard and brittle from vibration and finally breaks. The workability resistance to corrosion, and lightweight of aluminum alloy are major factors in its adoption for aircraft tubing.

Aluminum Alloy Tubing. Aluminum alloy tubing, 1100 (1/2 hard) or 3003 (1/2 hard), is used for general purpose lines of low or negligible fluid pressures, such as instrument lines and ventilating conduits. Aluminum alloy tubing, 2024-T and 5052-0 are used in general purpose systems of low and medium pressure, such as hydraulic and pneumatic 1000 to 1500 psi systems. Tubing made either from 2024-T and 5052-0 material stands a fairly high pressure before bursting. These materials are easily flared and are soft enough to be formed with handtools. Be very careful when working or handling tubing to prevent dents, scratches, and nicks. For high pressure lines (3000 psi) requiring the use of aluminum alloy tubing, use 6061-T material.

Corrosion Resistant Steel Tubing. Corrosion-resistant steel tubing, annealed 1/4 hard, is used extensively in high-pressure (3,000 psi) hydraulic systems for the operation of the landing gear, flaps, brakes, and the like. External brake lines should always be made of corrosion-resistant steel to minimize damage from flying rocks during takeoff, landing, and from careless ground handling. In other systems, (regardless of the tube size), it is preferred that only stainless steel nuts be used. This will minimize the chances of the sleeve and nut cracking, a situation that can result from an overtorqued "B" nut.

Corrosion-resistant steel tubing does not have to be annealed for flaring or forming. In fact, the flared section of steel tubing becomes somewhat stronger from cold-working and strain-hardening during the flaring process; its higher tensile strength permits the use of tubing with thinner walls. The final installation weight is not much greater than that of the thicker walled aluminum alloy tubing.

Exercises (871):
After each of the following statements, indicate the type of tubing material required.

1. Repair of ventilating conduits.

2. Repair of low pressure lines.

3. Repair of external brake line.

4. Repair of a high pressure line requiring aluminum tubing.

5. Repair of instrument lines.

6. Repair of medium pressure lines.

7. Repair of landing gear lines.

872. Identify different types of aluminum alloy tubing materials by matching the correct color code to a specific type of aluminum alloy.

Before you make repairs to aircraft tubing, it is of the utmost importance that you make accurate identification of the material. This can be done easily by sight when a tubing, aluminum alloy, or steel is used as the basic material. However, it is quite difficult to determine whether a material is 1100, 3003, 5052-0, or 2024-T aluminum alloy material.

Tubing Color Codes. You may have to analyze a system as to the pressures involved and the fluid contained. Make hardness samples of the material by filing or scratching with a scriber, or compare code markings of the replacement parts with the original installation. Always refer to technical orders for information and to check the accuracy of your findings.

The actual alloy designation is stamped on the surface of the large aluminum alloy tubing. On small aluminum alloy tubing, the designation may be stamped on the surface, but more often it is shown by a color code. Bands of the color code, not more than 4 inches in width, are painted at the two ends and approximately midway between the ends of the tubing. When the band consists of two colors, one-half of the width of the color band is used for each color. The painted color codes used to identify aluminum alloy tubing are given in figure 5-1. For example, 2014 aluminum alloy is gray, and 6053 aluminum alloy is black.

System Coding. For identification of the various fluid lines, code bands of colored tape are placed around the tubing near the system units and joints, and at intermediate points. This permits easy tracing of the line or system throughout the aircraft. If more information is needed to identify plumbing lines by color code band marking, consult TO 1-1A-8.

Exercises (872):
Match the color codes given in Column 2 with the aluminum alloys in Column 1. Not all the colors are used.

Column 1	*Column 2*
_____ 1. 7075	a. White
_____ 2. 2024	b. Purple
_____ 3. 6061	c. Brown and yellow
_____ 4. 1100	d. Red
_____ 5. 5052	e. Black
	f. Blue and yellow
	g. Gray

873. Specify if statements related to the types and uses of tubing fittings are correct and correct the incorrect statements.

Types of Tubing Fittings. Fittings are used with aircraft tubing to connect one piece of tubing to another or to system units. Fittings are made in many shapes and forms, as shown in figure 5-2. The ones you are primarily concerned with, are those that must be installed on the tubing itself, such as, the flared (AN) and flareless-tube (MS) types.

Flared-tube (AN) fitting. The AN standard fitting is the most commonly used flared tubing assembly for attaching tubing to the various fittings required in the tubing systems of an aircraft. The AN standard fittings include the AN818 nut and AN819 sleeve. The AN817 sleeve nut incorporates the functions of both the AN818 nut and AN819 sleeve. The AN819 sleeve is used in conjunction with the AN818 coupling nut. All of these fittings have straight threads, but they have different pitch for the various types. The size of these fittings is given in dash numbers that equal the nominal tube outside diameter (often indicated by the letters OD) in sixteenths of an inch.

The flared-tube fitting, shown in figure 5-3 (upper section), consists of a sleeve and a nut. The sleeve fits directly over the tubing and one end is countersunk at the same angle as the tubing flare. The nut fits over the sleeve and when tightened, draws the sleeve and tubing flare tightly against the male fitting connector to form the seal. The male fitting has a cone-shaped surface with the same angle as the inside of the flare. The sleeve supports the tubing so that vibration does not concentrate at the edges of the flare, and distributes the stresses over a wider area for added strength.

Flareless-Tube Fitting (MS). The flareless-tube fitting shown in figure 5-3, consists of a sleeve and a nut. Notice that the tubing is not flared. In order to effect a seal between the tubing and the sleeve, an operation called presetting (discussed later) is carried out. The connector has a counterbore, a portion of

Aluminum Alloy	*Color*
1100	White
3003	Green
2014	Gray
2024	Red
5052	Purple
6053	Black
6061	Blue and Yellow
7075	Brown and Yellow

53-1806

Figure 5-1. Aluminum alloy identity color codes.

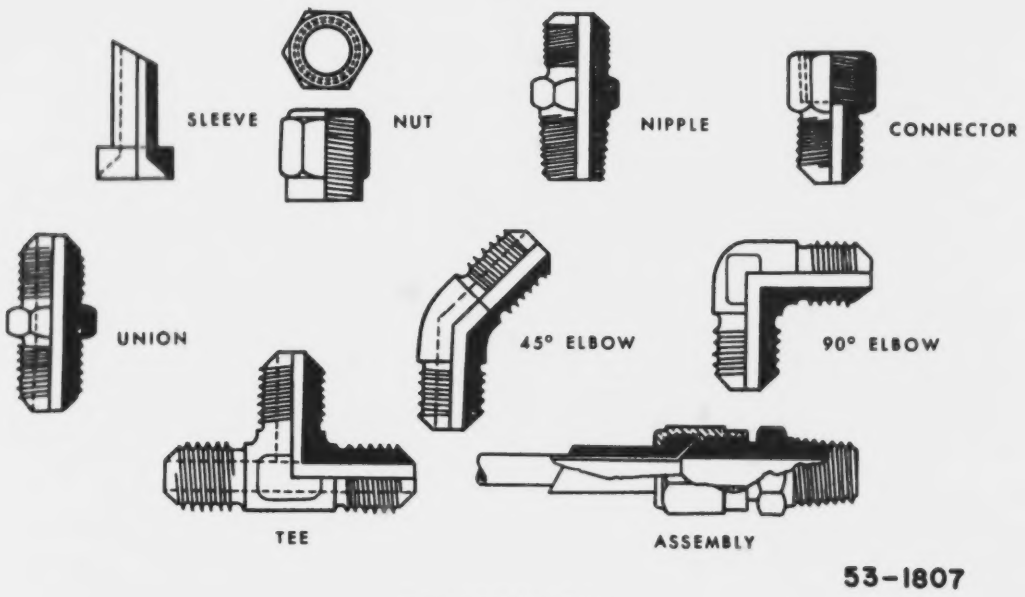


Figure 5-2. Tubing fittings.

which is beveled 24°. The seat in the connector forms a stop for the tube, and the beveled area causes the sleeve to seal the connection as the nut is tightened.

There are two types of flareless-tube fittings in current use. The newer most widely used type consists of a long sleeve (MS21922) and short nut (MS21921) as shown in figure 5-4. The older type consists of a short sleeve (MS21918) and a long nut (MS21917). Flareless-tube fittings are made of aluminum and steel.

Uses of Tubing Fittings. Both AN and MS fittings are easily identified by their distinguishing colors, blue for aluminum alloy and black for carbon steel. Corrosion resistant steel fittings are natural color. To minimize occurrence of sleeve cracking and resultant relaxing of initial "B" nut torque, do not install aluminum alloy sleeve on any airborne system. On airborne systems where aluminum tubing is employed, a stainless steel sleeve and an aluminum alloy "B" nut is recommended. Aluminum alloy sleeve installed on airborne systems should be replaced on an attrition basis. Aluminum alloy sleeve may be employed with aluminum alloy tubing and aluminum "B" nuts on Aerospace Ground Equipment and all non-airborne systems.

Steel fittings are used with steel tubing. For corrosion prevention, aluminum alloy lines and fittings must be anodized. Steel lines and fittings, if not stainless steel, must be plated to prevent rusting or corroding. Steel fittings are usually cadmium plated, although some come plated with nickel, chromium, or tin.

Exercises (873):
If one of the following statements is correct, mark it true; if it is false, correct it.

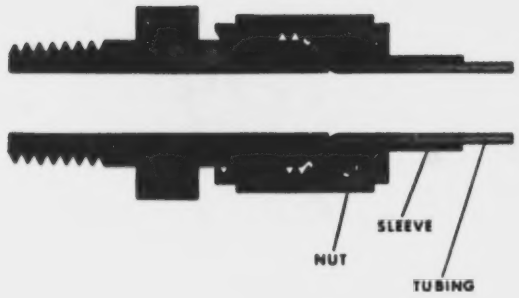
____ 1. Both the AN and MS tubing fittings consists of a sleeve and a nut.

____ 2. The AN819 sleeve nut incorporates the functions of the AN818 and AN819 sleeve.

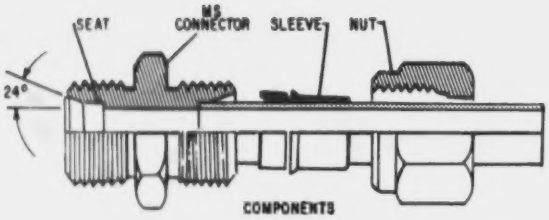
____ 3. The sizes of aircraft fittings are equal to the outside diameter of tubing.

____ 4. Corrosion-resistant steel fittings are identified by a black color.

____ 5. Aluminum tubing fittings are identified by a natural aluminum color.



FLARED – TUBE FITTING



FLARELESS – TUBE FITTING

Figure 5-3. Flared (AN) and flareless (MS) fittings.

___ 6. To minimize sleeve cracking, only stainless steel sleeve should be used on aircraft tubing systems.

874. Given descriptions of damaged tubing lines, indicate whether the line should be replaced or repaired.

Damage Evaluation Criteria. Damages such as chaffing, galling, or fretting produce mechanical property changes in metal tubing material that greatly reduce the ability to withstand internal pressure and vibrations. Any visible penetration of the tubing wall surface (any visible damage to or removal of metal from the tubing wall) by chafing, galling, or fretting is cause for:

a. Correction of the conditions that originated the damage.

b. Replacement or repair of the tubing assembly or damaged section regardless of the type metal, system media or pressure ranges involved.

Damages such as dents, nicks, or scratching of tubing can be minimized by using care. Most damage of this kind occurs from careless handling of tools during maintenance of the aircraft.

Dent limitations. Any dent less than 20 percent of the tubing diameter is not objectionable and should be repaired, unless it is on the heel of the short bend radius. In this case, the tubing must be replaced. Dents can be removed from tubing by drawing a bullet through the tubing. The diameter of the bullet must be equal to or slightly less than the inside diameter of the tubing.

Nick limitations. A nick no deeper than 15 percent of the wall thickness of aluminum, aluminum alloy, or steel tubing may be reworked by burnishing with hand tools. Any aluminum, aluminum alloy, or steel tubing carrying pressure in excess of 100 psi with nicks in excess of 15 percent of the wall thickness should be rejected. Nicked tubing is weakened due to internal pressure, and such nicks must be burnished out to reduce a possible notch effect. If the nicks are not burnished out, consequent stress concentration under vibration will cause weakening and eventual breaking at the nicked point. Burnishing removed the notches by removal of surrounding material. Burnishing is not allowed in the heel of bends where the material has already been stretched thin during forming. Tubing that is nicked in a bend should be replaced if it carrying over 100 psi. For tubing carrying pressure of 100 psi or less, a nick no deeper than 20 percent of the wall thickness of aluminum alloy or steel tubing may be reworked by the use of burnishing handtools.

Exercises (874):
Indicate whether a section of damaged tubing described in each statement should be repaired or replaced.

1. The depth of a nicked area on a steel tubing is equal to 25 percent of the wall thickness.

2. A dent which is less than 15 percent of the tubing diameter is located on a straight section of the tubing.

3. A nick has been burnished out on the heel of a bend in a piece of aluminum tubing.

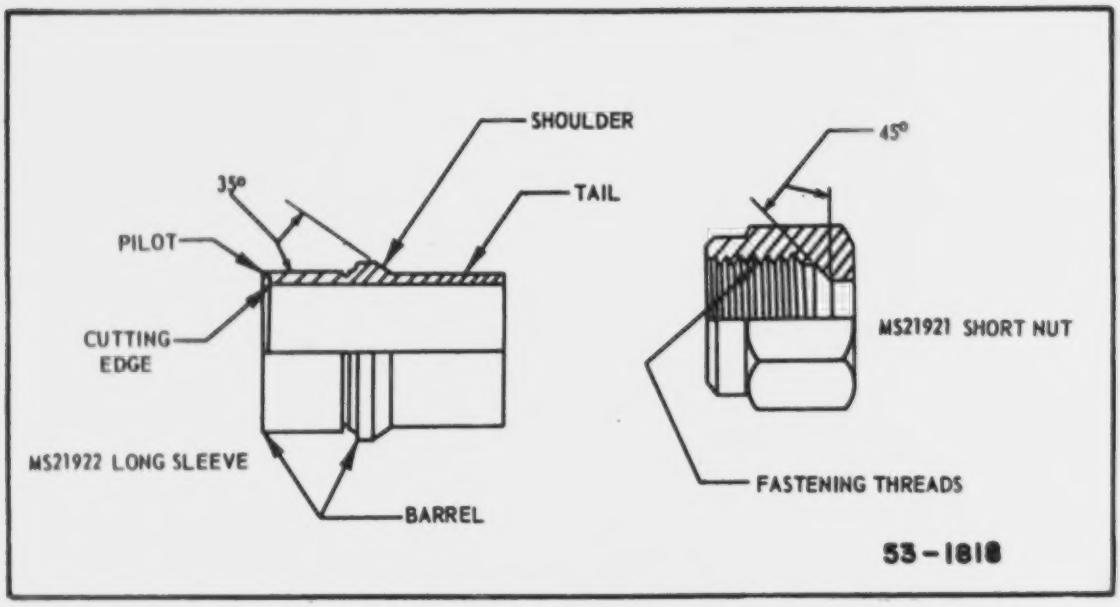


Figure 5-4. Types of flareless (MS) fitting.

4. A dent is located on the heel portion of a bend.

5. The depth of a nicked area on aluminum alloy tubing carrying a pressure of 100 psi is equal to 10 percent of the wall thickness. The nick is located on a straight section of the tubing.

875. Given work situations involving the repair or replacement of tubing assemblies, cite the proper procedures to use.

General Procedures. Damaged tubing and lines should be replaced with new items whenever possible. Sometimes replacement is impractical and repair is necessary. Scratches and abrasions and minor corrosion on the outside of lines may be considered negligible and can be smoothed out with a burnishing tool or aluminum wool. Limitations as to the amount of damage that can be repaired in this manner are prescribed in applicable technical orders and should be rigidly followed. If a line assembly is to be replaced, the fittings often can be salvaged; then the repairs will involve only tubing forming and replacement.

Forming. Remove the old assembly, taking care not to further damage or distort it, and use it as a forming template for the new part. The old assembly employed as a template should give you a duplicate as to length, bends, and angles. If you are rerouting a line or if the old assembly is not available, make a template of wire, bending the pattern by hand as required for the new assembly. Then bend the tubing to conform to the wire pattern.

Never select a route that does not require bends. A tubing cannot be cut or flared so accurately that it can be installed without bending and still be free from initial mechanical strain. Never make a direct straight-line connection between two fixed attachment points. Bends are necessary to permit the tubing to expand or contract under temperature changes and to absorb vibration. If the tubing is small in diameter (under 1/4 inch) and can be hand formed, then add definite bends to avoid a perfectly straight assembly.

Start all bends at a reasonable distance from the fittings, because the sleeve and nuts must be slipped back during the fabrication of flares and during inspections. In all cases, the new tubing assembly should be so formed before installation that it is not necessary to pull the assembly into alignment. Supports, such as clamps and brackets, must be provided at intervals. The requirements for these supports are usually listed in a table of specification conveniently located in the aircraft.

Cutting. To insure a good tubing connection, the tubing should be cut squarely and deburred. Tubing may be cut with a tube cutter or a hacksaw. When a large number of tubing assemblies are to be made, a band saw or contour metal cutting saw can be used to speed up the cutting operation. Under normal work

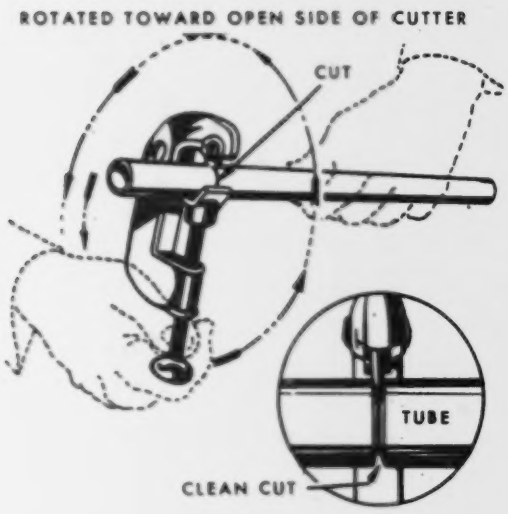


Figure 5-5. Tube cutter.

situations, the tube cutter is the preferred method cutting tubing. The tube cutter shown in figure 5-5, is adaptable for use with any soft metal tubing such as, aluminum, or aluminum alloy.

Place the tubing in the cutting tool with the cutting wheel at the point where the cut is to be made. Rotate the cutter around the tubing, applying a light pressure to the cutting wheel by intermittenly twisting the thumbscrew. Too much pressure on the cutting wheel at one time could deform the tubing or cause excessive burring. The cutting wheel should be adjusted downward only while the cutter is being rotated, as dents will be made in the tubing if the cutter is not moving. If the tube cutter is used properly, no objectionable burrs will result. However, if too rapid feeding of cutter wheel has caused an internal burr, remove the burr with the three-cornered scraper, normally located in the handle of the cutter. The cutting wheel should be replaced at intervals to maintain a sharp cutting edge.

If a tube cutter is not available, a five tooth (32 teeth per inch) hacksaw may be used in cutting tubing. A convenient method of holding tubing when cutting it with a hacksaw is to place the tubing in a flaring block and clamp the block in a vise. After cutting tubing with a hacksaw, remove all saw marks by filing. After filing, remove all burrs and sharp edges from the inside and outside of the tube as shown in figure 5-6. Clean out the tubing and make sure no foreign particles remain. If chips, fillings, or burrs are not removed before flaring, they will be pressed into the flare and cause pock marks. Pock marks, scratches, draw marks or other surface irregularities on a flare, make tight sealing impossible.

Specific Precautions. Oxygen tubing requires special attention because of the fire hazards caused by leaks and because of the importance of always keeping sufficient line operating pressure. Consult TO 1-1A-8 and the -2 series for specific type aircraft when attempting repairs on an aircraft oxygen tubing system.

Prior to installation of fittings (AN/MS) in the oxygen system, it is recommended that each fitting be visually or airflow checked to insure passages are free from obstructions. Leakage at oxygen fittings may sometimes be corrected by tightening; but remember, excessive tightening can weaken or destroy the connections. Always use a torque wrench and follow the tables given in TO 1-1A-8.

Do not use thread compounds on flared tubing used in oxygen systems. Limit the use of thread compounds to tapered male pipe threads. TO 1-1A-8 and the -2 series for a specific aircraft must be carefully followed at all times when fabricating, installing, and inspecting oxygen system plumbing.

Cleaning and Sealing of Tubing. Before a new tubing assembly is installed on an aircraft, it must be clean and free of any foreign materials such as metal shavings, dust, dirt, oil, grease, etc. If the tubing assembly is to be used on oxygen systems, take special care to insure that it is completely free from grease or oil, since these agents cause a violent reaction when they come in contact with oxygen.

After the tubing is formed and the ends flared, all oil, grease, and foreign material should be removed from the tubing by flushing the assembly with trichloroethylene, then use compressed air to blow the tubing assembly clean and dry. If trichloroethylene is not available, aliphatic naptha will do. When the tubing assembly is to be used on oxygen systems, special cleaning procedures outlines in TO 1-1A-8 *must* be followed. After a tubing assembly has been cleaned, the ends of the tubing should be sealed against dirt and dust. Use screw-in plugs or plastic dust covers (caps). If neither of these is available, use tape to seal the tubing ends. Prior to installation of the tubing assembly on an aircraft, remove the seals and inspect for cleanliness.

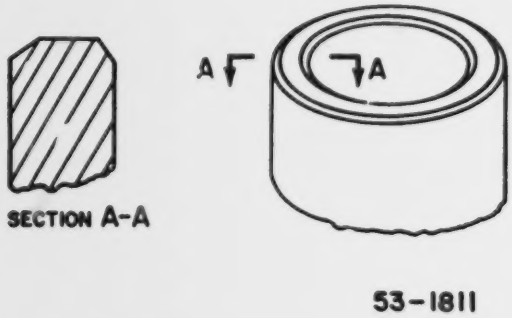


Figure 5-6. Properly prepared tubing end.

Exercises (875):

1. What should you use during the manufacturing of a replacement piece of tubing, to determine correct angles and bends of the new piece of tubing?

2. What should you do in order to determine the locations of bends and angles in a replacement section of tubing when the old tubing or blueprints are not available?

3. If tubing connections are in a straight line between two points, what must you do to the replacement piece of tubing?

4. When selecting a type of saw to cut tubing, what factor must you remember?

5. To avoid deforming or causing excessive burring when using a tube cutter, what should you do?

6. When cutting tubing using a hacksaw, what method of holding the tubing should you use?

5-2. Bending of Aircraft Tubing

Tubing can be bent with any one of a variety of bending tools or it can be bent without the aid of tools by carefully forming the desired radius by hand; however, this crude method should be used only in the absence of proper tools. Our discussion will cover four methods of bending tubing; the hand tube bender, the mechanical (vise mounted) tube bender, the production tube bender, and the filler methods.

876. Specify work procedures used when bending tubing with a hand tube bender.

Hand Tube Bender. Soft tubing up to 1/4-inch diameter may be bent by hand without flattening or buckling if care is taken to work the curve gradually, provided the tubing is not used in oxygen system. (Tubing used in oxygen systems should not be hand formed). For sizes larger than 1/4-inch diameter, the hand tube bender shown in figure 5-7, provides smooth, accurate bends in thin-walled tubing of soft materials. The hand tube bender shown is available in sizes to accommodate tubing ranging from 3/16 to 1 inch outside diameter. Sizes are usually stamped on the bender in 1/16-inch stages. The radius block is graduated in dimensions of 15° from zero to 180°.

Bending Procedures. Most of the time you will be fabricating a new piece of tubing using the original tubing as a template. Certain duplicating procedures along with proper bending procedures must be used if an acceptable replacement is to be fabricated. When using the hand tube bender to make a single bend tubing assembly, follow these steps:

a. Select the correct diameter and type of tubing to use.

b. Cut the tubing material to the approximate length required.

c. Estimate the amount of material required to make the first bend and mark the replacement tubing. This mark indicates the START of the bend. Allow enough tubing material for the flare.

d. Position replacement tubing into hand tube bender by holding the radius block handle stationary in your left hand. With your right hand, raise the slide bar handle as far as it will go. (NOTE: Under certain conditions, it may be necessary to place the radius block handle in a bench vise. This allows you to use both hands during the bending steps, especially if steel tubing is being bent.)

e. Rotate slide bar handle back to its original position and at the same time, place the retaining clip over the tubing. The retaining clip holds the tubing firmly in place during the bending step.

f. Adjust the slide bar handle so that the full length of the groove in the slide bar is in solid contact with the tubing. Recheck the alignment of the bent mark and zero setting on the radius block.

g. Make the bend by rotating the slide bar handle downward until the desired angle of bend is obtained on the radius block. An alignment mark is provided on the face of the slide bar to determine when the required angle is obtained. Springback, for certain types of materials, must be taken into consideration. (See fig. 5-7.)

h. Remove the bent tubing simply by lifting the slide bar handle back to its original position. Swing the clip aside and remove the tube.

i. Determine the amount of material needed for the remaining sections of tubing by placing the new and original tubing side by side, aligning the starting points of the bends. Mark the required amount for both ends (flare allowances must be included) on the new tubing (use the original tubing as a template). At this point, you're ready to cut the tubing to the proper size.

When fabricating a new piece of tubing that has two or more bends, you need additional procedures to insure correct distance and angles between bends. The first bend should be bent following the previously covered procedures for single bends with the exception of step i. It is after this, that additional steps are needed. These are the steps to follow:

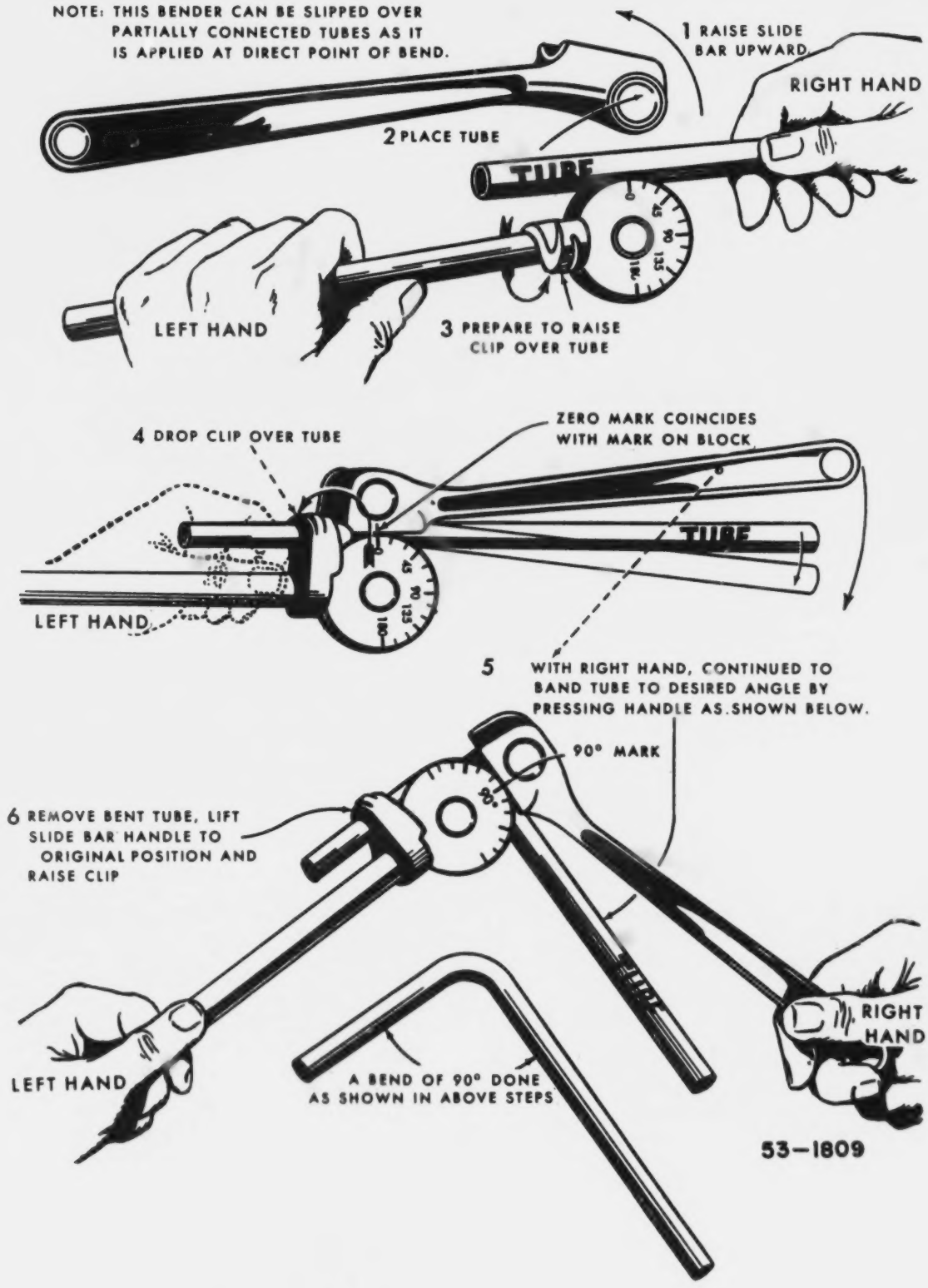

NOTE: THIS BENDER CAN BE SLIPPED OVER PARTIALLY CONNECTED TUBES AS IT IS APPLIED AT DIRECT POINT OF BEND.
1 RAISE SLIDE BAR UPWARD.
RIGHT HAND
2 PLACE TUBE
TUBE
LEFT HAND
3 PREPARE TO RAISE CLIP OVER TUBE
4 DROP CLIP OVER TUBE
ZERO MARK COINCIDES WITH MARK ON BLOCK
TUBE
LEFT HAND
5 WITH RIGHT HAND, CONTINUED TO BAND TUBE TO DESIRED ANGLE BY PRESSING HANDLE AS SHOWN BELOW.
90° MARK
6 REMOVE BENT TUBE, LIFT SLIDE BAR HANDLE TO ORIGINAL POSITION AND RAISE CLIP
RIGHT HAND
LEFT HAND
A BEND OF 90° DONE AS SHOWN IN ABOVE STEPS
53—1809

Figure 5-7. Hand tube bender procedures.

a. Locate the starting points of all bends on the original tubing. This is accomplished by inserting the original tubing into the hand bender just as if you were going to increase the bend radius of the bent areas. Position the retaining clip in place and insure the slide bar is firmly on the tubing. Your set-up should look as if you had just completed the bend.

b. Maintain a slight downward pressure on the slide bar handle, place an alignment mark on the tubing directly above the zero on the radius block. This will show the STARTING point of the bend.

c. Repeat steps "a" and "b" for all bends in the original tubing.

d. After you have established all starting points, take the replacement tubing and align the starting point of the first bend with the one on the original tubing. Both tubes should be side by side and be as close together as possible. Rotate the replacement tubing to match any bend angles in the original tubing.

e. Holding both tubes together, mark on the replacement tubing the starting point of the second bend on the original tubing. This establishes the correct distances between bends.

f. Position the replacement tubing into the hand tube bender as previously described. Before bending, rotate the replacement tubing to match any bend angles in the original tube. By holding the original tubing near the inserted replacement tubing in the hand tube bender, you can find the angle.

g. After the bend angle have been allowed for, bend the second bend.

h. Remove the replacement tubing from the hand tube bender and check the alignment by placing both tubes side by side.

Exercises (876):

1. How is the start point of a bent on a piece of tubing having only one bend radius located?

2. How are the cut off points on a replacement piece of tubing having only one bend radius located?

3. How are the starting points of bends in an original piece of tubing having more than two bends developed?

4. How is the necessary distance between two bends on a replacement piece of tubing developed?

5. How are the required bend angles on a replacement piece of tubing developed?

877. Specify operating procedures or capabilities of given tube duplicating machines.

Mechanical Tube Bender. The tube bender shown in figure 5-8 is issued as a kit. The kit contains the equipment necessary for bending tubing from 1/4 inch to 3/4 inch in diameter.

This tube bender is designed for use with aircraft grade, high strength, stainless-steel tubing, as well as all other metal tubing. It is designed to be fastened to a bench or tripod, and the base is formed so as to provide a secure grip in a vise.

The simple hand bender shown in figure 5-7 uses two handles as levers to provide the mechanical force necessary to bend the tubing. This type tube bender employs a handcrank and gears. The forming die is keyed to the drive gear and secured by a screw (fig. 5-8).

The forming die on the mechanical tube bender is calibrated in degrees similar to the radius block of the hand type bender. A length of replacement tubing may be bent to a specified number of degrees or it may be bent to duplicate the bend in the damaged tube or pattern. Duplicating the bend of a damaged tubing or pattern is accomplished by laying the pattern on top of the tubing being bent and slowly bending the new tubing to the required bend. NOTE: certain types of tubing are more elastic than others; therefore, it may be necessary to bend the tubing past the required bend to allow for springback.

Production Tube Bender. The manually operated production bender shown in figure 5-9, is designed to bend all sizes of aluminum material tubing from 3/8 of an inch to 1½ of an inch outside diameter and steel tubing from 3/8 of an inch to 1 inch outside diameter. Construction of the bender permits changing radius, clamp and slide blocks for each size of tubing and bend radius required. Benders are equipped with a mandrel rod stop assembly and suitable mandrels to handle thin wall tubing.

If tubing wall thickness is such that mandrel is required, suitable mandrel and mandrel rod must be selected. The mandrel rod must be of such length that with adjustment on the mandrel rod stop assembly, the mandrel can be properly positioned. A properly selected mandrel will fit snugly into the tubing but it still will slide in or out freely. Standard mandrels are available for all standard tubing sizes and wall thicknesses. Each mandrel is marked with the tubing diameter size and wall thickness of the tubing with which it should be used. Different size mandrels are required for different wall thicknesses even though the outside diameter of the tubing may be the same.

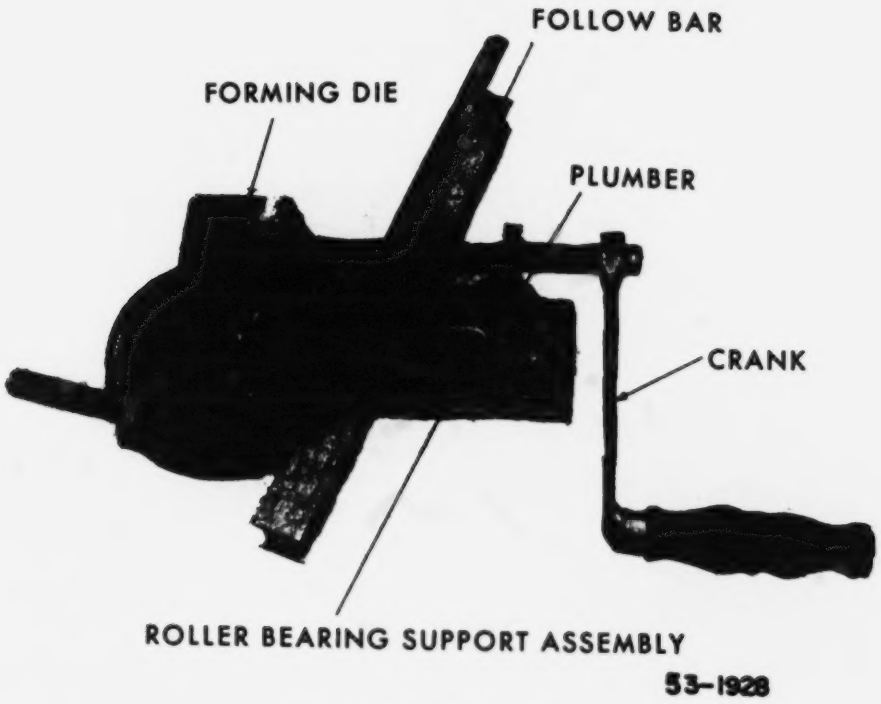


Figure 5-8. Mechanical tube bender.

Mandrel adjustment. For average bending, the mandrel should be adjusted so that the scribed line on its circumference is 5/8 of an inch behind the line scribed on the face of the radius block. When making this adjustment, be sure the radius block is at the o° position. The mandrel may be moved forward slightly to produce a more perfectly rounded tubing cross-section, or it may be moved slightly backward to ease bending effort. However, extremes in either direction may cause wrinkling, breaking, or flattening of tubing.

Radius block setup. The radius blocks are mounted on the two center posts located in the gear housing assembly. The radius block should be placed with the longer of the two sides adjacent to the slide block and clamp block. The shorter side is used when a previous made bend makes it impossible to use the longer side. Radius blocks, as well as clamps and slide blocks, are accurately milled and cored. Care should be taken to avoid nicking the ground surfaces.

Clamp and slide block positioning. The clamp block is used to firmly grip the tubing during the bending operation. The clamp block is installed in the clamp block vise and positioned under the spring adaptor. The slide block is used to guide the tubing into the radius block during the bending operation. The slide block should be adjusted firmly against the tubing, but not with sufficient pressure to prevent the slide block from sliding through the slide block vise jaw. A film of grease can be used to aid in sliding. In bending heavy wall or steel tubing, a piece of emery cloth may be inserted between the tubing and clamp block to prevent slipping.

Bending. Bending is done by means of a hex wrench handle operating through a 40 to 1 gear ration. For small, thin wall tubings, the bender may be turned directly by pulling on the clamp block vise arm. Procedures used for duplicating tubing having more than one bend, are the same as discussed for the hand tube bender.

Trouble shooting. After the bend is formed in the tube, it should look like the piece of tubing shown in the upper right corner of figure 5-10, this is the result of having the mandrel not far enough forward in the tubing.

When the bend is kinked as shown in the lower right hand illustration of figure 5-10, is usually caused by the tubing slipping in the bender. The tubing must be firmly clamped by the clamp block to prevent slippage during the bending process. Wrinkled bends, lower left hand illustration in figure 5-10, is produced when thin wall tubing is bent without a supporting mandrel. A complete tubing breakage occurs when the mandrel is too far forward in the tubing.

Exercises (877):

1. What is the largest size tubing that you can bend on the mechanical tube bender?

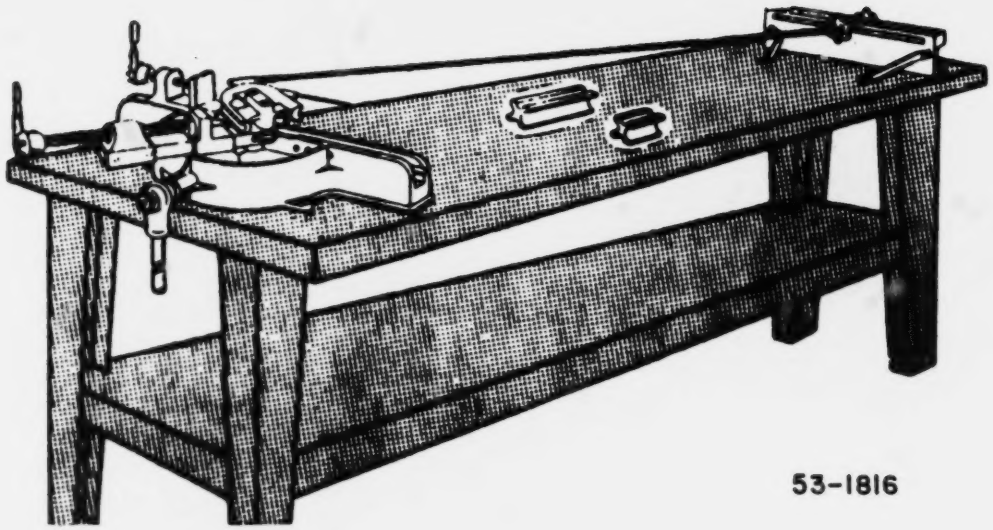


Figure 5-9. Production tube bender.

2. How is bending force applied to the tube when using a mechanical tube bender?

3. When is it necessary to use a mandrel when using a production tube bender?

4. To aid in producing a perfectly rounded tubing cross-section when using a production tube bender, what can you do?

5. How should the slide block be adjusted when using a production tube bender?

6. How should the clamp block be adjusted when using a production tube bender?

7. After each of the tubing defects listed, state the work procedure you would take to eliminate the problem when using a production tube bender.

   a. Tubing is flattened.

   b. Tubing is kinked.

   c. Tubing is wrinkled.

   d. Tubing separates upon bending.

878. Specify typical procedures to follow when using a filler material to aid in bending tubing.

When hand or production tube benders are not available or are not suitable for a particular bending operation, a filler of metallic composition or dry sand may be used to facilitate bending. When using this method, cut the tubing slightly longer than required. The extra length is for putting a plug (which may be wooden) in each end.

Metallic Composition Methods. This method involves the use of a fusible alloy. Prior to inserting the fusible alloy into the tubing, one end of the tubing is closed to prevent leakage of the fusible alloy. The tubing and ladle containing the fusible alloy is immersed in a tank of water at or near the boiling point until the alloy is melted. The melting point of the fusible alloy is 71° C. (160° F.). For ordinary tubing lengths, a hot water tank similar to that used in plating departments may be used. For longer lengths, a special tank may be constructed or a length of pipe

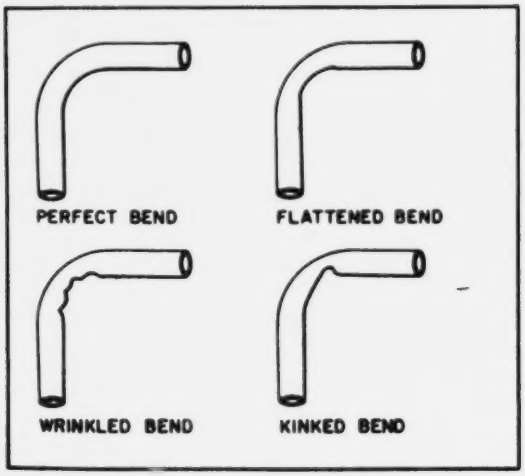


Figure 5-10. Tube bending requirements.

used so that both the tubing and the ladle will be completely submerged. When the fusible alloy has melted, pour it into the tubing. Keep both the tubing and the ladle beneath the surface of the hot water during the pouring operation so that the molten alloy will displace the water in the tubing. Remove the tubing from the hot water and cool it with cold water or allow it to air cool until the fusible alloy solidifies. The tubing can then be bent with a bending machine or blocks can be formed.

The fusible alloy should be cold when the tubing is being bent, and the tubing should be bent slowly. When the bending operation is completed, the fusible alloy can be removed from the tubing by immersing both the tubing and ladle in the tank of hot water and pouring the alloy back into the ladle. When pouring the alloy back into the ladle, keep both the tubing and ladle beneath the surface of the hot water, as this reduces the tendency of the alloy to stick to the inside of the tubing.

Never apply a torch or flame to tubing or fusible alloy, as excessive heat will destroy both the strength of heat-treated tubing and the melting characteristics of the fusible alloy. Boiling water will not melt fusible alloy after a flame has been applied. If a flame is used to remove the fusible alloy, particles of the alloy may stick to the inside of the tubing, causing corrosion.

Sand or Shot Method. In an emergency, aluminum alloy may be bent or formed by filling the tubing with shot or sand. After plugging one end, fill and pack the tube with fine, dry sand and plug tightly. Both plugs must be tight so they will not be forced out when the bend is made. The tube may also be closed by flattening the ends or by soldering metal discs in them. After the ends are closed, bend the tubing over a forming block shaped to the radius specified in the technical order. Make certain that all particles of the filler are removed after bending so that none will be carried into the system in which the tubing is installed.

Exercises (878):

1. When inserting a fusible alloy into a piece of tubing, how can you displace the water in the tubing?

2. How long should you wait after inserting the fusible alloy into the tubing before forming the tubing?

3. After the bending is accomplished using a fusible alloy, how is the fusible alloy be removed?

4. When using a filler material such as sand, to aid in bending tubing, how may the ends of the tubing be sealed?

5-3. Flaring and Swaging of Aircraft Tubing and Fittings

The particular work procedure used to install tubing fittings will depend on the type fitting being used. For the flared-type (AN) fitting, the tubing must be flared, while the flareless type (MS) fitting is swaged on the tubing. Regardless of which type you are installing, you must follow specific guidelines to insure that, when the tubing assembly is installed on the aircraft, the fittings properly seal the tubing.

879. From a list of statements about tubing flares, identify the true statements and explain why the others are not correct.

Two kinds of flares are generally used in aircraft tubing systems, the single flare and the double flare. Either kind may be used when you use a three-piece solderless (AN) union. Because every three-piece (AN) fitting requires a flare and is used only in critical places, correct tube flaring is important. Flares are frequently subjected to extremely high pressure; therefore, the flare on the tubing must be properly shaped or the connection will leak or fail. Although incorrectly formed flares may seem to mate up satisfactorily and pass initial pressure tests, they are not to be depended upon for continuous service. To insure proper seating, the flare should conform to requirements of the fitting being used for connecting the tubing.

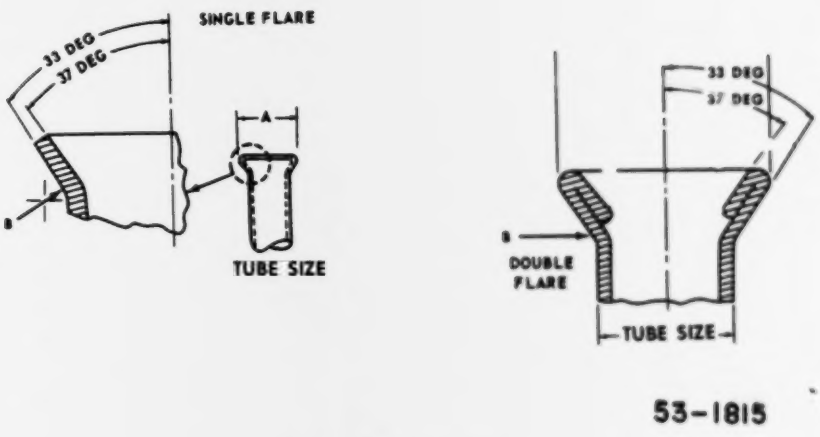


Figure 5-11. Flaring angles.

Diameter and Length Requirements. If flaring tools have been used properly, the flare diameter will be correct. The outside diameter of the single flare should extend approximately 1/16 of an inch beyond the end of the sleeve, but should not be wider than the largest outside diameter of the sleeve. On tubes flared too short, full clamping of the fitting is not used and the flare may be squeezed thin due to small area of the tubing that is clamped. Such joints do not offer maximum security against leakage, breakages at the flare, or pull out strains. If the flare is too short, correct it by reflaring the tubing.

Tubes flared too long will stick and jam on threads (during assembling) and are likely to seat against the bottom of the male fitting rather than on the tapered seat. Strong wrench pressure cannot be depended upon to bring such flares to a tight seat. If a flare is too long, it should be cut off and the tube end reflared.

Angle Requirements. The flare angle of the tubing should be directly related to the flare angle of the male fitting. Incomplete flares cannot be depended upon to draw down properly on the fitting seat. In such cases, the sleeve tends to climb up on the flare, leaving very little grip on the tubing after the fitting is assemblied. For best results, complete all flares to the proper angle. Figure 5-11, illustrates the angles required for both single and double flares.

Squareness Requirements. Flares should be square and concentric with the tubing and fitting sleeve to seat properly, unfortunately, they instead may be out of square and eccentric because the tubing was not cut off square and the flare was unevenly formed in the flaring tool. One method of checking the squareness of a cut, prior to flaring, is to temporarily install a tubing sleeve backwards on the tube. The back edge of the tubing sleeve can be used as a gage to check the squareness of the cut. When flares are out of square and eccentric, they should be cut off and done over.

Exercises (879):
Identify each true statement and explain why the others are false.

1. Either type of flare (single and double) can be used with a three-piece solderless union.

2. The outside diameter of a flare should be 1/16 of an inch larger than outside diameter of the sleeve.

3. A flare that is too short can be corrected by increasing the torque requirement of the clamping nut.

4. If a flare is too long, it should be filed down to correct size.

5. Squareness of cutting procedures can be checked using the back edge of a sleeve fitting.

880. Given operational procedures related to using the Roto-Master flaring machine, arrange them in their proper sequence.

Description. The Roto-Master flaring machine, shown in figure 5-12, is designed to manufacture single and double flares. Single and double flares can

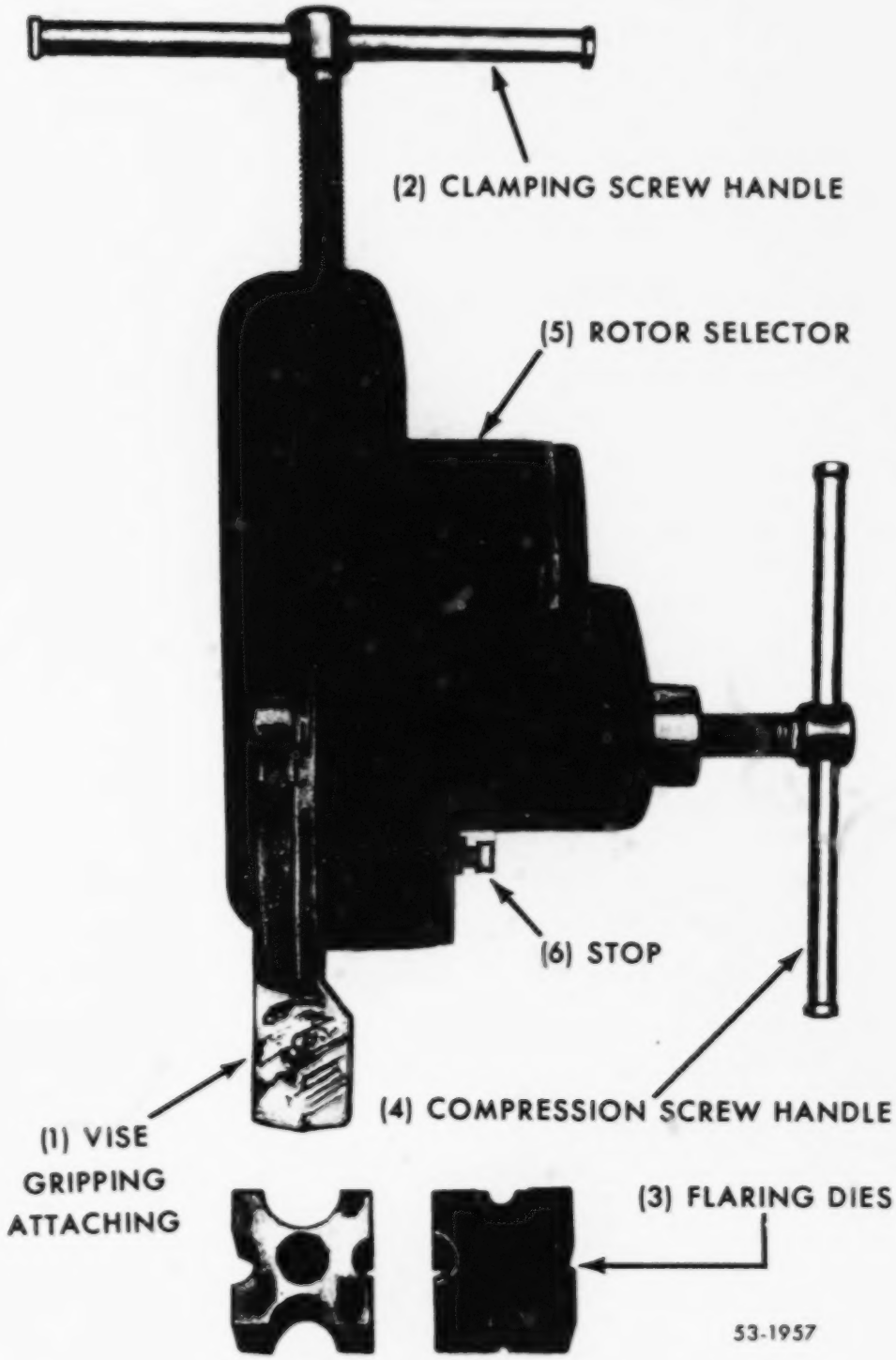


Figure 5-12. Roto-master flaring machine.

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be made in mild aluminum tubing, while only single flares can be made in all grades of steel tubing. The machine comes equipped with two sets of removable dies which can be used to flare tubing from 1/8 to 3/4 of an inch outside diameter. A vice gripping attachment is provided so that the machine can be mounted in a bench vise during flaring operation. The procedures for single and double flares are somewhat different, and must be closely followed to produce an acceptable flare.

Double Flaring Procedures. The procedures to use when double flaring are as follows: (NOTE: Numbers refer to numbers shown in figure 5-12.)

a. Cut tubing so that it is square. The inside and outside of the tubing edges should be rounded to a small radius.

b. Mount the machine in a bench vise so that the dies, after being inserted, will face toward you. Use the vise gripping attachment (1).

c. Rotate the clamping handle (2) counterclockwise until it stops turning. Rotating the handle, moves the clamping screw upward allowing the needed clearance to install the required set of flaring dies (3). Also, this permits previously installed dies to be removed.

d. Rotate the compression handle (3) counterclockwise, until it stops turning. This action moves the flaring cone outward, permitting easy removal and insertion of the lower die.

e. Select the proper set of dies (4) that correspond to the outside diameter of the tubing being flared.

f. Insert the flaring dies, making sure that the tapered portion of the dies are facing toward the flaring cone and the die halves are properly matched. Diameter sizes are marked on each die to aid in matching the dies together.

g. Rotate the rotor (5) located on the side opposite the dies until the size tubing being flared appears in the sight opening at the tip of the rotor.

h. Separate flaring dies slightly and insert tubing until it is solidly against the first punch. Holding the tube firmly against the punch, tighten the handle clamping (2) until the tubing is held tightly in place. NOTE: Make sure the stop (6), located on the bottom of the die chamber, is in the DOWN position.

i. Now tighten the compression handle (4) down as far as it will travel. Larger diameter tubing will require slightly more pressure in this operation than the smaller tubing. This operation completes the first part of the double flare.

j. Rotate the compression handle (4) to the "out" position again. Rotate the rotor (5) until the word "cone" appears in the sight opening. (The cone punch completes the second operation for all tubing sizes on double flares).

k. Tighten compression handle inward until a slight resistance of the screw is felt. The amount of pressure required to form the second part of the double flare, will depend in your experience with the machine. It is recommended that you perform a few practice flaring operations to get the proper "feel" for the pressure required.

l. Release both the handles and remove the tubing from the machine. Inspect the flared area. *Under* flaring is more desirable than *over* flaring due to the draw up of the tubing fittings.

Single Flaring Procedures. Follow the same procedure as that for double flaring with these exceptions:

a. The rotor (5) is positioned in the cone position during all phases of the flaring operation.

b. The slide tube stop (6) located on the bottom of the machine, must be in the UP position prior to inserting the tubing in the dies. The stop (6) permits only the necessary amount of tubing needed for the flare to extend beyond the dies.

Precautions. When double flaring tubing 1/2 and 3/4 in diameter, be sure the compression handle during the upset operation is forced down to its extreme travel. Smaller sizes will require less pressure. Also, never grip the tubing twice in the same place, as the tubing will be slightly compressed from the first gripping. The second gripping will not clamp firmly, especially for double flaring. The compression screw should never be run completely down without the flared dies installed.

Exercise (880):

1. Arrange the following work procedures, related to forming a double flare when using a Roto-Master flaring machine, in their proper sequence. Some procedure are repeated.
   a. Insert flaring dies.
   b. Insert tubing.
   c. Mount machine in bench vise.
   d. Rotate clamping handle outward until it stops.
   e. Rotate rotor to the cone position.
   f. Rotate compression handle outward until it stops.
   g. Rotate rotor to the tube diameter being flared.

h. Remove tubing from flaring dies.

i. Prepare tubing material.

j. Tighten clamping handle inward.

k. Tighten compression handle inward.

l. Remove tubing from flaring dies.

m. Tighten compression handle.

n. Release both handles.

o. Inspect flare.

881. Specify procedures related to using a single flaring machine.

Single Flaring Machine. The single flaring machine, shown in figure 5-13, is an electric motor driven machine for easy, speedy production flaring of annealed, aluminum, steel or stainless steel tubing. With readily interchangeable heads and accessory attachments, it can be used also for squaring, burring, and beading of tubing. The machine produces perfect, concentric, smooth-surfaced standard 37° flares for use with AN tube fittings.

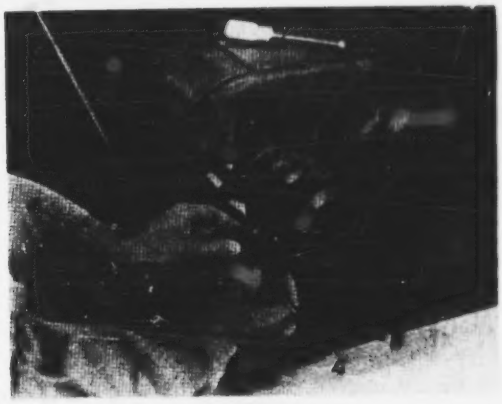
On some models, a single handle motion closes the tubing vise to grip the tubing. A pull on the operating lever then moves the flaring center to the tubing for the flaring operation, while other models are equipped with an air cylinder that closes the tube vise automatically when the operating lever is moved. Model AP232, figure 5-13, is automatic in both operations—tubing gripping and flaring. It efficiently flares the full range of standard tubing wall thicknesses and all sizes from 1/8 inch through 2 inches outside diameter. By means of a variable speed pulley, speed rotary flaring center can be controlled to suit the weight and material of tubing being flared. Accurately machined flaring dies hold the tubing firmly without marring the tubing surface. Flaring dies are available for each tubing size. The flaring cone revolved freely on an eccentrically-mounted bearing, rolling the tubing out against the flare die. In beading, forward movement of the operating lever causes the beading tool, by cam action, to press outward against the inside of the tubing, forcing it into the bead-forming die. The flarer is driven by an electric motor mounted inside the housing of the machine. The hand lever that controls the rotating spindle for flaring is located on the front of the machine.

Flaring Operations. When flaring tubing using the single flaring machine, certain specific steps must be followed in correct sequence in order to produce an acceptable flare. The specific steps in their correct sequence are outlined in the following paragraphs. It is recommended that you make a few practice flares before flaring the new tubing assembly.

Flaring center adjustment. Insert the flaring center into the chuck (step 1, fig. 5-14). The degree of eccentricity of cone can be varied, thus permitting the flaring center to accommodate tubing from size 2

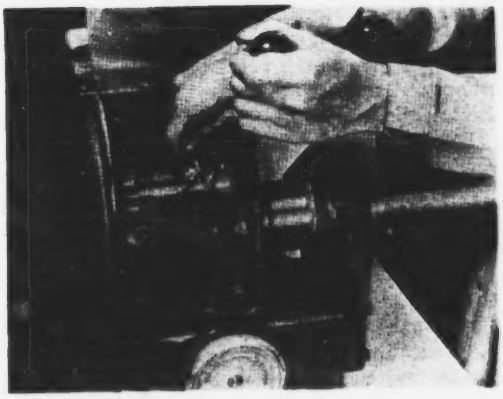
Figure 5-13. Single flaring machine.

STEP 1



STEP 2

STEP 3



STEP 4

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Figure 5-14. Flaring operation—single flaring machine.

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(1/8" outside diameter) through 32 (2" outside diameter). For smallest size tubing, cone must be most nearly on center. For flaring larger sizes of tubing, the cone can be more widely off center. To make this eccentricity adjustment, simply turn the flaring center within the spindle head by hand. On the spindle head is scribed an index line. Around the flaring center is a gradational scale scribed for tubing outside diameters. For flaring a given size of tubing, match the tubing outside diameter mark on the flaring center scale with the index line on the spindle head. Lock the flaring center in place by tightening the spindle head set screw.

Inserting flaring dies. The semi-circular flaring dies (step 2, fig. 5-14), with 37° flaring angle, fit into the vise jaws to hold the tube securely without marring tube surface. A separate set of dies is available for each tubing size 2 through 32. Each set has a size marking. Select the proper size for tubing to be flared. Slide the dies into channels in vise jaws. Lock each half in place by turning the knurled circular key (step 2, fig. 5-14) into the arc slot in the flaring die.

Air-operated vise. Place the tubing in the lower half of the flaring die, pushing the tubing forward against the tube stop finger. The clamping vise is automatically closed to hold the tubing when the hand lever is brought forward in the flaring operation. The vise should close at very beginning of the spindle stroke, as determined by micro-switch that is actuated by the end of stop finger lever. The set screw that contacts the switch provides for an adjustment to cause the vise to close at slightest movement of the spindle. If the tubing is over or under size, make necessary compensation by turning the vise adjusting nut (step 2, fig. 5-14).

Tube stop finger. Attached to the inside or lower vise jaw, is a stop finger (step 3, fig. 5-14) to limit the extend of the tubing beyond vise toward the cone. Move the stop finger inward or outward with the finger adjustment screw (step 3, fig. 5-14), and tighten the lock nut (step 3, fig. 5-14) securely to retain the desired adjustment. When flaring, the tube should be approximately flush with the face of the flaring dies. The finger automatically retracts, as the spindle is advanced. Timing of reaction can be adjusted by means of the cam on the gear shaft, so any adjustment of the cam may necessitate readjustment of the set screw contacting the switch.

Variable speed control. Before making a trail flare, note the rotation speed. Turn the crank on the side of machine to vary speed (turn only while motor is running), as required to suit the wall thickness and material of the tubing being flared. Generally, for annealed thin wall aluminum tubing, use a full rotating speed. For medium size steel tubing of normal thickness, use a medium speed. For larger, heavy wall steel tubing, use a moderately slow speed. For stainless steel tubing, the slowest speed possible is necessary. The proper speed will produce a smooth "ironed" flare surface. Excessive speed may produce a rough surface or even split the extreme edge of the tube. With a little experience, you will become a competent judge of the proper speed for any given tubing.

Spindle travel stop. Place the tubing against the stop finger and clamp it in the vise for a trail flare. Bring the hand lever forward slowly to let the cone roll out the tubing wall against the flaring die. Bring the lever the full distance necessary to make a complete flare, but not so far as to thin out the flared section of the tubing. At this point, set the spindle travel stop with the adjusting screw dial nut (step 4, fig. 5-14) and secure adjustment with the companion lock nut (step 4, fig. 5-14) found on the threaded rod beneath the housing lid. With the spindle travel stop properly set, the hand lever can be pulled forward more rapidly and with safety for repetitive flaring.

Flare examination. After making the trail flare, return the lever to its original position. If the flare is not satisfactory, make further adjustments as necessary. If the wall of the flare has been thinned out, correct the spindle travel stop setting. If the flare surface is rough or end of the tubing is split, reduce the rotating speed. If the flare diameter is too large, adjust the stop finger to hold the end of tubing more nearly flush with the inside flate surface of the flaring dies. All adjustments are simple to make. With a little experience, you will readily learn to set up the machine quickly for flaring. The seating surface of the flare of some materials, especially steel, is vastly improved by applying a lubricant such as heavy oil or grease directly to the tubing end before flaring.

Exercises (881):

1. How is the flaring cone on a single flaring machine adjusted for various diameter tubing?

2. How are the flaring dies positioned into the vise jaws of the single flaring machine?

3. If you were flaring annealed thin wall aluminum tubing, how is the rate of speed adjusted and to what speed?

4. When it becomes necessary to adjust the travel of the spindle on a single flaring machine, how should it be adjusted?

5. For each of the flaring defects listed, state the correct work procedure to employ to eliminate the cause of the problem.

Defect	*Corrective Action*
a. Flare is thinned out.	a.
b. Flare surface is rough.	b.
c. Flare is too large.	c.
d. Flare is split.	d.

882. Describe the construction features and operating procedures to squaring and burring head assembly used on the pneumatic single flaring machine.

Before starting to flare or bead the tubing, it is essential to prepare the tubing by squaring the end and removing burrs from both inside and outside edges. The squaring and burring head is designed to accomplish this with one cycle of the operating lever.

Head Assembly. The head has an aluminum body that screws onto the spindle in place of the flaring head and chuck. It has on its face three milled slots designed to hold the three cutting tools rigidly in position. The squaring cutter, or bit, is self-supporting in the center slot. It is long enough to cover the whole range of the machine (1/8" through 2" O.D.) so does not require adjustment. Chamfering (outside) and countersinking (inside) cutters, or bits, are independent of each other, and each is held securely by a set screw in its own sliding tool holder. Adjusting screws against the ends of the tool holder aid in setting exact cutting positions. (See fig. 5-15).

Adjusting screws, and set screws for holding the three cutters in working position, are reached by a 1/8" socket wrench in the outer rim. An overhang on the outer edge of the body protects the operator from tools bits and flying chips.

Setup Procedures. The dies used for flaring are also used to hold the tubing for the squaring-burring operation. For squaring-burring, adjust the stop finger to permit the end of tube to extend sufficiently beyond the flaring dies (to avoid the danger of the squaring-burring blade coming in contact with the flaring dies).

To set up the head assembly, follow these steps:

a. To gain the maximum working space, when changing the heads, leave the hinged jaw open, remove the clamp blocks, and hold the stop finger retracted.

b. Be sure, when cutters are installed, that each cutting edge faces in the proper direction to perform its job. *The tool turns counter-clockwise.*

c. Insert the squaring bit in the center slot, and tighten the set screw. Once this bit is locked in its slot it need be removed only for sharpening or replacement. Should the cutting edge become worn at one point from repeated use on one size tubing, it can be shifted laterially 1/16" to present a fresh edge for the same size tube.

d. Insert the burring bits in the tool holders, being careful to have the proper bit turned at the correct angle. Put the tool holders in their slots and tighten the set screws. The bits should be located at a distance from the outside of the tube.

e. Insert the flaring dies of the proper size in the vise jaws, adjusting the clamping pressure to have a moderately firm grip on the tube.

f. Clamp the tubing in the jaws with enough length extending to permit the squaring bit to contact the end of the tubing without interference from the stop finger.

g. Take a cut with only the squaring bit contacting the tube. Make sure the entire end surface is faced.

h. With the spindle stopped, hold the head against the tubing. Loosen one of the tool holders and move it until the bit touches the holder, then make a further one-quarter turn to move the cutter bit into the tubing. Set the other cutter bit in the same manner. Lock both tool holders securely, and make a trail cut.

i. Inspect the cut. The entire end of the tubing must be machined smooth. The inner and outer edges should be lightly chamfered to remove sharp edges uniformly. Excessive chamfering, especially on thin wall tubing, is not desirable. Adjust tool holders until satisfactory chamfers are made.

If one side of the tubing shows more inside chamfer, and the opposite side more outside chamfer, it is due to a misalignment between spindle and vise jaws. Adjustment of the bits will not correct this condition. The usual cause is accumulated tolerances and clearances of tubing, dies or jaw opening; or particularly on soft tubing, the closing down of the tubing as it is clamped. To compensate, shim the lower dies up a few thousandths of an inch until the cut is true.

j. Set the stop finger to get the proper tubing position before cutting, and then limit the burring by setting the travel stop.

Figure 5-15. Squaring and burring head assembly single flaring machine.

k. If much stock must be removed, do so by a series of short, light cuts. Move lever control forward in short strokes until the full amount has been removed.

Exercises (882):

1. How are the cutters arranged on the squaring-burring head?

2. How is the operator protected from the bit and flying chips during squaring-burring operations?

3. How is the tubing held in place during the squaring-burring operation?

4. Where should the stop finger be set during the squaring-burring operation?

883. Arrange, in the proper order, the individual procedures required when accomplishing various operations using a double flaring machine.

Descriptions. The double flaring machine, shown in figure 5-16, is a pneumatic operated flaring machine, It is designed to produce a double flared on annealed ferrous or non-ferrous tubing and to also produce upset beading. This machine will double flare-tubing up to 1/2 inch outside diameter. Single flares may be produced with the machine by omitting the upset operation. Single flare up to 3/4 inch diameter can be formed.

Figure 5-17 shows the necessary forming tools (punched and die) needed when using this machine. The punches are selected for use based on the outside diameter and wall thickness of the tubing being flared. Flare punches are available in either 37° or 45°. The lower portion of figure 5-17 illustrates the set-up of both punches on the retracting attachment assembly.

Operation Procedures. Before flaring a new tubing assembly, you should practice on sample pieces to check out the operation of the machine. You should never operate the machine without tubing being in the die. This faulty procedure will damage the die or the punches. To operate the machine, follow the procedure outlined in the following paragraphs.

Punch set-up procedures. To change punches for a different wall thickness and diameter, the tool bar (shown in the lower portion of fig. 5-17) is removed with the air ON as follows:

a. Set the operating lever to a space between the flare and up-set positions to prevent accidential firing of the power unit. Close the valve on the power unit chamber.

b. Push the knurled retaining knob out of the tool bar.

c. Slide the tool bar out of the machine.

d. Change punches as required.

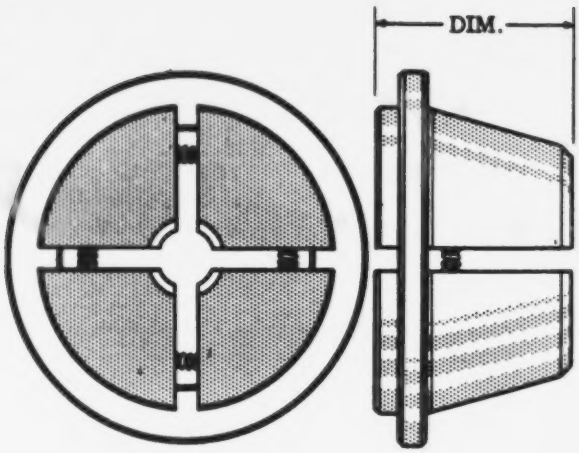
e. Slide the tool bar back into the machine.

f. Replace knurled knob back into tool bar.

g. Turn power unit valve to OPEN position. The machine is ready to use.

Die changing procedures. To change the die, the air supply must be turned off, and the air bled from the system. When the air is turned off, set the operating lever to a position nearest the main casting. Push lever back, then pull forward until the die remains open. Remove the nose ring with a spanner wrench and

Figure 5-16. Double flaring machine.

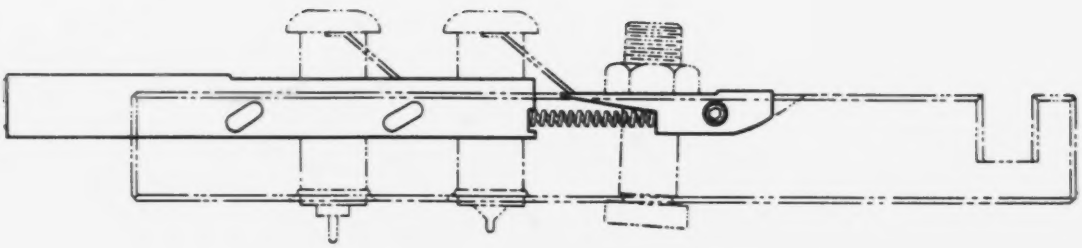


FLARE DIE

FLARE PUNCH

UPSET PUNCH

FORMING PUNCHES



TOOL BAR PUNCH RETRACTING ATTACHMENT ASSEMBLY

53-1827

Figure 5-17. Double flaring machine—dies and punches.

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change the die. Once changed, re-install the nose ring and tighten with the spanner wrench. Turn the air supply back ON and the machine is ready to operate.

Flaring sequence. Once the proper set of punches and the correct die are installed, the individual air pressure requirements must be adjusted. For each type of tubing material and wall thicknesses being used, different pressure settings are required. A comparison of two types of material settings for a tube having a wall thickness of 0.028 are:

	Type Material	*Upset Pressure*	*Flare Pressure*
1.	Aluminum-5052-0	26	22
2.	Aluminum-6061-T	32	28

NOTE: Also, the tube stop adjustment must be adjusted for each different wall thickness.

The flaring sequence is as follows:

a. Make necessary air pressure adjustments.

b. Move the operating lever to position No. 1, shown in section A of figure 5-18. Push the lever toward the rear of the machine (position 1A shown in section B of fig. 5-18). This position will open the die's jaws, so you can insert the tubing.

c. Insert the tubing until it contacts the tube stop. Pull the operating lever forward to the number 1 position, as shown in portion B of figure 5-18. This action closes the dies and clamps the tubing in place.

d. Move the operating lever to the extreme outboard position. This is the upset position. (No. 2 position shown in portion A, of fig. 5-18).

e. Move the operating lever towards the rear of the machine. This will fire the power unit. Position 2A is shown in section B of figure 5-18. In some cases, the power unit must be fired twice for thicker wall thicknesses.

f. Move the operating lever towards the center portion No. 3. This is the flaring position. Position 3 shown in section A, of figure 5-18.

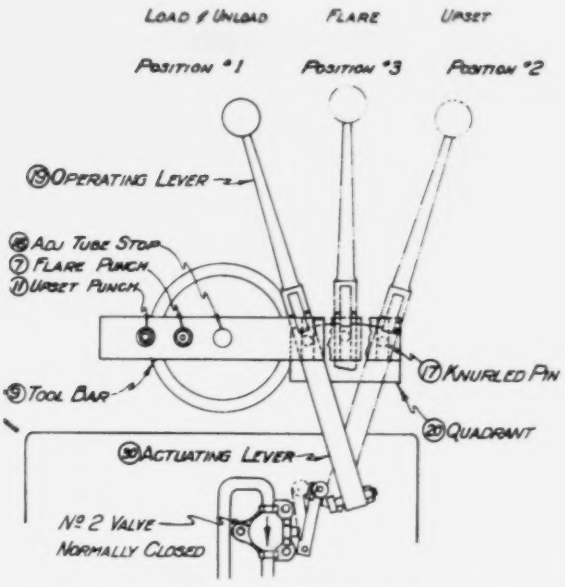
g. Move the operating lever towards the rear of the machine. This will fire the power unit. Position 3A is shown in section B, of figure 5-18.

h. Move the operating lever to the number 1 position again and push the lever towards the rear of the machine. This will open the die so the tubing can be removed.

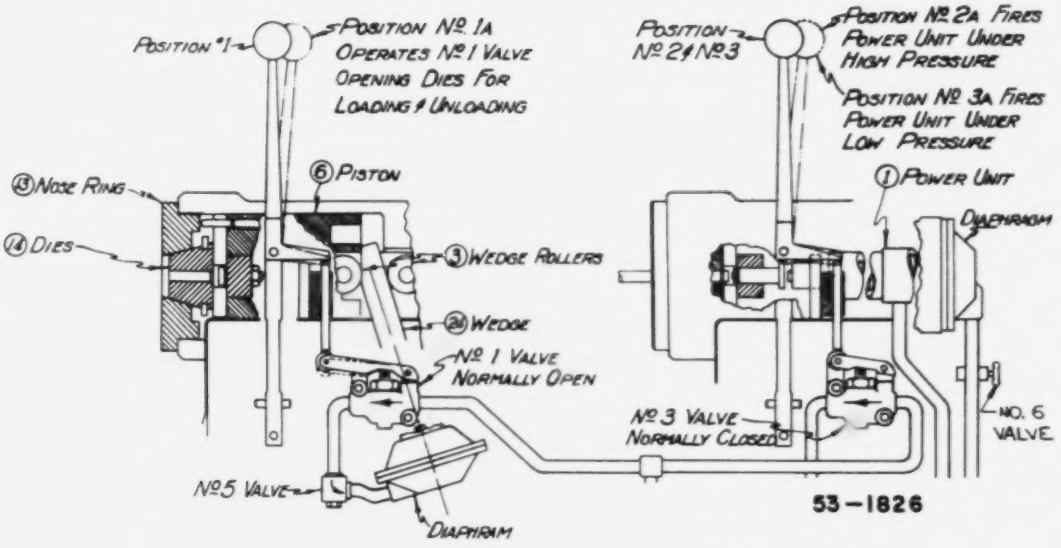
Exercises (883):

1. Arrange the following work procedures required when changing the punches in the tool bar for a double flaring machine, in their proper sequence.
   a. Slide tool bar out of the machine.
   b. Push out the knurled retaining knob out of the tool bar.
   c. Set operating lever in a space between the flare and upset position.
   d. Change punches as required.
   e. Replace retaining knob in tool bar.
   f. Replace the tool bar back into machine.

2. Arrange the following work procedures required, when flaring tubing, using the double flaring machine in their proper sequence.
   a. Insert tubing into dies.
   b. Move operating lever towards the rear of the machine, closing dies.
   c. Move the operating lever to the flaring position and push the lever inward, firing the power unit.
   d. Make necessary air-pressure setting.
   e. Move operating lever to the upset position and push the lever inward, firing the power unit.
   f. Move the operating lever to the No. 1 position, opening the dies.
   g. Return the operating lever to the No. 1 position, opening the dies.
   h. Remove the tubing from the dies.



A. LATERAL LEVER POSITIONS



B. FRONT AND BACK LEVER POSITIONS

Figure 5-18. Flaring sequence—line positioning locations.

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884. Identify true statements related to the process of beading aircraft tubing.

Beading Aircraft Tubing. In aircraft tubing systems, rubber hoses are attached to metal tubing, in the same manner as the hoses attached to your automobile cooling system. In such cases, it is necessary to fabricate a bead on the metal tubing to insure a no-leak connection. Beading is the process of fabricating a raised ridge (bead) around the outside surface of metal tubing.

Tubing may be beaded with a hand operated machine or a roller type machine, such as the power tube flaring machine with special dies designed exclusively for beading. (See fig. 5-19.) The hand operated beading machine is the most commonly used. Two rollers are required for beading operations. The inside roller fits inside the tubing and is equipped with a male bead. The outside roller fits on the outside of the tubing and is equipped with a corresponding female groove. With sufficient pressure applied, the male bead will press the tubing into the female groove, thus forming a bead on the outside of the tubing.

The hand beading tool is used with tubing having 1/4- to 1-inch outside diameter. The bead is formed by using the beader frame with the correct rollers attached. The inside and outside of the tube is lubricated with light oil to reduce the friction between the rollers during beading. The sizes marked in sixteenths of an inch on the rollers are for the outside diameter of the tubing that can be beaded with that size roller. Separate rollers are required for the inside of each tubing size, and care must be taken to use the correct parts when beading. The hand beading tool works somewhat like the tube cutter in that the roller is screwed down progressively. In addition, a small vise (tube holder) is furnished with the kit.

Other methods and types of beading tools and machines are available, but the hand beading tool is the most used. As a rule, beading machines are limited to usage with large diameter tubing over $1^{15}/_{16}$ inch unless special rollers are supplied. The grip die method of beading is confined to small tubing. A hose clamp is always used for securing the rubber to the beaded tube. The bead and hose clamp combination also ensure that the hose will not slip off the tubing as long as the hose clamp is reasonably tight.

Exercises (884):
Indicate whether each of the following statements is true or false by marking T or F in the space provided.

____ 1. Beading is the process of fabricating rounded flares on the ends of metal tubing.
____ 2. The inside roller used when beading has a grooved surface.
____ 3. The outside roller has a raised center ridge for beading the outer surface of the tubing.
____ 4. Hand beading can be accomplished on tubing up to 1 inch in diameter.
____ 5. The sizes of the beading rollers are marked in sixteenths of an inch to match the inside diameter of the tubing being beaded.
____ 6. Beading machines are usually limited to usage with large diameter tubing over $1^{15}/_{16}$ of an inch.

885. Cite aspects of the procedures and tools used when swaging flare-less tube (MS) fittings.

Presetting Factors. Although the use of flareless-tube fittings eliminates all tube flaring, another operation referred to as PRESETTING, is necessary prior to installing of a new flareless-tube assembly. Presetting is necessary to form the seal between the sleeve and tube prior to final installation in a flareless seat. The presetting operation described here concerns the newer type—long sleeve (MS21922) and short nut (MS21921) fittings.

Assembly of a flareless tube fitting involves an operation termed presetting, whereby the sleeve is set onto the tubing in an initial operation before final installation in a flareless seat. Just how tight the nut must be to set the sleeve will vary, depending on whether a mandrel is used during the sleeve presetting operation. A mandrel consists of a short piece of solid bar of any hard material, such as steel, with an outside diameter from 0.002 to 0.005 inch less than the inside diameter of the tube. Its use is not mandatory in presetting sleeves but is recommended, since it supports the inside diameter of the tube and assists in attaining an improved sleeve cut during the presetting operation. For field use, a short piece of drill rod of the proper diameter may be used as a mandrel. The length of the mandrel should be such that, when inserted in the tubing, it provides support of the tube inside diameter at the sleeve cut and also at the point where the sleeve shoulder grips the tubing. Although a hand

Figure 5-19. Single flaring machine beading die setup.

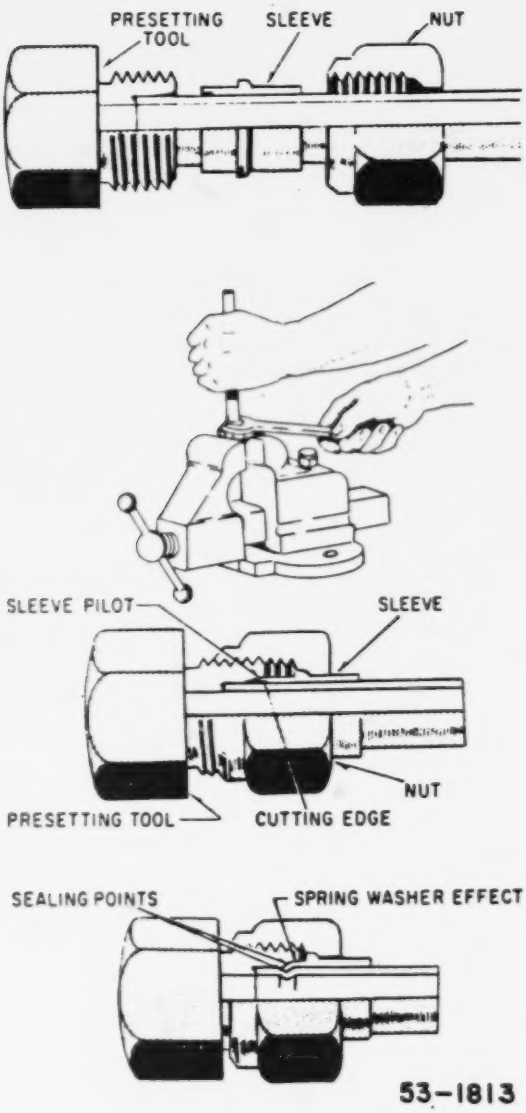

Figure 5-20. Presetting of MS tubing fittings.

presetting tool is desirable, a standard flareless fitting connector can be used. An aluminum fitting should be used only once for presetting, and a steel body should be used no more than five times.

Presetting Procedures. The following steps described the sequence of presetting a flareless-tube fitting.

a. Cut the tubing to the correct length, with the ends perfectly square. Burr the inside and outside of the tubing. Slip the nut and then the sleeve over the tubing. (See fig. 5-20.) If a mandrel is used, insert it in the tubing at this time.

b. Lubricate the threads of the presetting tool and the nut. Place the tool in a vise, hold the tubing firm and square on the seat in the tool. (Tubing must bottom firmly in the tool.) The tubing should be rotated slowly between the thumb and fingers while the nut is turned down until the cutting lip of the sleeve seizes on the tubing. When the tubing no longer turns, the nut is ready for final tightening.

c. Tighten the nut to the number of turns specified in TO instructions. Normally, one full complete turn plus an additional 1/16th of a turn is required. This permanently swages the sleeve to the tubing. Sleeves should not be removed from tubing and re-used under any circumstances.

Inspection. (See fig. 5-21.) After presetting, uncouple nut from threads of presetting tool and inspect sleeve and tube for the following:

a. The sleeve cutting lip should be embedded into the tubing outside diameter approximately 0.003 to 0.008(1) (Numbers refer to numbers in fig. 5-21) depending on the size and material of the tubing. A lip of material will be raised under the pilot(2). The pilot of the sleeve should contact or be quite close of the outside diameter of the tubing(3). The tube projection from the pilot of the sleeve to the end of the tubing(4). will be approximately as listed in figure 5-22.

b. The sleeve should be bowed slightly (6).

c. The sleeve may rotate on tubing and have a longitudinal movement on tube of not more than 1/64 inch.

d. The sealing surface of sleeve(5) which contacts the 24° angle of the fitting body seat should be smooth, free from scores, and showing no longitudinal or circumferential cracks. Crazing cracks in the plating are not detrimental to the safety or function of the fitting.

e. The minimum internal tubing diameter at the sleeve cut(7) should not be less than the valves outlined in TO specifications.

f. As a final check to determine the fitting is properly preset, the tubing assembly should be proof tested at a pressure equal to twice the intended working pressure.

Exercises (885):

1. How does the mandrel used during the presetting of MS fitting, compare to the inside diameter of the tubing?

2. What can be used in place of the presetting tool?

3. At what time, after the tubing has been inserted into the presetting tool, is final tightening accomplished?

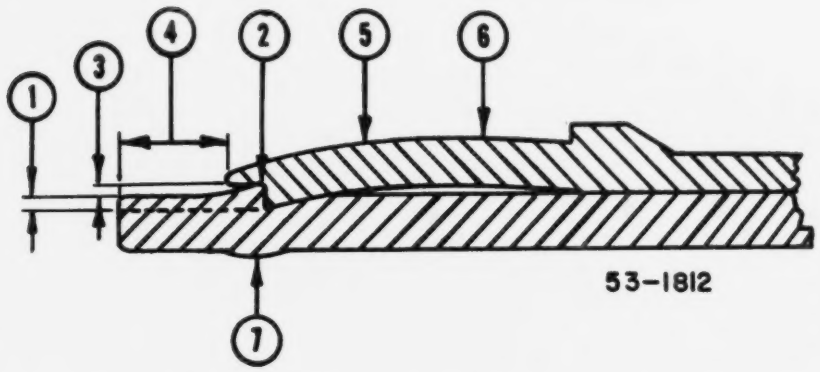

Figure 5-21. Sleeve inspection requirements—MS fittings.

4. Normally, how many turns of the nut is needed to swage the sleeve to the tubing when using MS fittings?

5. Which part of an MS fitting cannot be reused?

6. How much should the cutting lip of a MS sleeve be embedded in the outer surface of the tubing after swaging?

7. After a sleeve has been swaged in place, what types of sleeve movements are allowed?

8. How should the final test of a swaged sleeve retention be performed?

886. From a listing of statements about the procedures and equipment used to repair tubing using the Permaswage method, identify the accurate statements, and explain why the others are not inaccurate.

Permaswage Method. The Permaswage repair procedures provides the capability and technique for the permanent repair of damaged tube assemblies. Permaswage is designed for use by all levels of maintenance. The basic element of the repair technique is the Permaswage fitting that is mechanically swaged onto the tubing by a hydraulically operated tool. Fittings are available in configuration including permanent unions and shapes (elbows, ties and crosses), flared and flareless separable sleeves, and unions as well as combinations of permanent and threaded fittings.

This repair technique is applicable only to tubing assemblies not exceeding the material-line size-operating pressure as specified in TO guidelines. The repair method is not to be used with annealed corrosion-resistant steel or 5052 aluminum tubing. Permaswage fittings are manufactured using 21-6-9 corrosion-resistant steel, and they are compatible only with certain type of corrosion resistant alloys, titanium alloys, and only 6016-T6 aluminum alloy. Permaswage tube fittings should not be installed in any system until authorization is permitted in the applicable system technical order. For detailed instructions on required specifications and techniques, consult TO 1-1A-8, section XIII.

Required Equipment. The tools and equipment needed to accomplish Permaswage repairs are shown in figure 5-23. The purpose and use of each tool is described in the following paragraphs.

Tube size	Approximate tube projection (inches)
3/16	7/64
1/4	7/64
5/16	5/32
3/8	11/64
1/2	3/16
5/8	13/64
3/4	7/32
1	15/64

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Figure 5-22. Tube projection requirements—MS fittings.

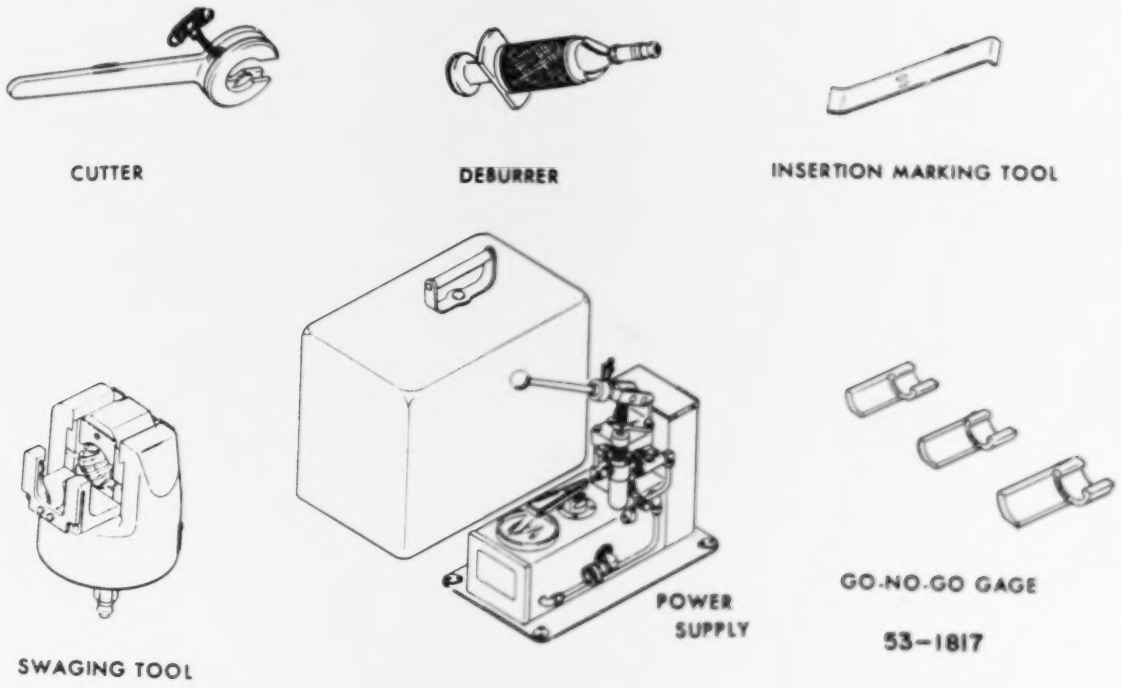


Figure 5-23. Permaswage tools.

Chipless tube cutter. Three chipless tube tools accommodate tubing sizes from 3/16 of an inch through 1½ of an inch. The cutters have a built-in ratchet assembly that permits the cutter to be used in tight places so tubing may be cut on the aircraft. Before using a cutter, verify that ratchet is operating freely and the cutting blade is in the full OPEN position. The cutting blade can be adjusted to compensate for various diameters and wall thicknesses by turning the drive screw with a "T" handled wrench.

Deburrer tool. Special deburring tools remove burrs from the inside diameter (ID) of the tubing. The tool consists of a plunger-activated stem subassembly, incorporating an elastic plug that is inserted into the tube end up to the point where the cutter makes contact with the burr. Deactivation of the plunger causes the elastic plug of the stem subassembly to expand, thus creating an interference fit with the ID of the tube. Hand rotation of the knurled tool body operates the cutter and accomplishes the deburring, while the elastic plug prevents chips generated during the deburring operation from entering the tubing. Three sizes of tools are provided that enable deburring of all size tubing from 1/4 of an inch through 1½ of an inch outside diameter (OD). Each tool is provided with stem sub assemblies to allow precise matching to the sizes within its ranges.

Insertion marking tool. Insertion marking tools are an accurate and consistent method of marking the tubing at a prescribed distance from the tube ends for proper tube insertion into the fitting. A lip stop allows the end of the tool to overlap the tube and position it for marking. A .300" wide slot in the tool exposes the correct area to be marked. A special felt tip marking pen is available to use to mark the tube.

Swaging tool. There are three swage tools that cover tubing size ranges of: 3/16" to 3/8", 1/2" to 3/4", and 1" to 1½". Each tool consists of a swage body and removable sets of die block assemblies to match each tube and fitting size. Die block assemblies consist of upper and lower die blocks. The lower die block remains in the swage tool, while the upper one is removable to enable the tool to be positioned around the fitting prior to swaging.

Hydraulic power supply. A portable hydraulic power supply generates the pressure to actuate the swaging tool. A swaging pressure of 5500 psi is applied to all swage tools. A relief valve keeps the pressure from exceeding the required swaging pressure. Upon completion of the swaging operation, pressure is manually reduced to zero with a selector valve. An integral air-to-hydraulic intensifier provides the required pressures when actuated by either hand pumping or 60-100 psi shop air.

Go-no-go gage. Go-no-go inspection gages are used to check completed Permaswage joints for length of tube-fitting engagement, outside diameter of the swaged-fitting, and the length of the swaged portion of the fitting. There is a gage for each fitting size from 3/16" through 1½"

Exercises (886):
Identify each true statement and explain why the others are false.

1. The basic element of Permaswage repair techniques involves mechanically swaging tubing fitting to tubing by hydraulically operated tools.

2. Permaswage repairs can be accomplished on all types of tubing material.

3. The chipless tube cutter used when repairing tubing using Permaswage method, has a built-in ratchet to save time when cutting tubing.

4. Separate chipless tube cutters are needed for each diameter and wall thickness of tubing.

5. The elastic plug on the deburring tool used when repairing tubing using the Permswage method, prevents chips from entering the tubing.

6. The insertion marking tool is used to indicate the positioning of the Permaswage fittings on the end of the tubing.

7. Swage pressure required when swaging Permaswage fittings is between 60 to 100 psi.

Balancing and Alignment of Aircraft Structures

DO YOU REMEMBER what happened when you lost your balance while you were learning to ride a bicycle? Quickly you learned how necessary it is to have equal pressure on the handlebars to keep your balance. If you have watched a balancing act on TV or at the circus, you are aware of the importance of balance and the skill of the performer in maintaining the bar in a balanced horizontal position. If the performer were to lose this balance, he would fall. Likewise, the craft might plunge to earth.

In terms of aircraft structure, proper alignment is essential to safe, economical, and reliable operation. An aircraft out of alignment is unsafe. Yet aircraft are subjected to many varied and intense stresses and are, therefore, likely to get out of alignment. Because high speeds and altitudes increase hazards due to misalignment, alignment checks of aircraft increase in number and frequency with increase in speed and performance.

As an Airframe Repair Specialist, you will be called upon to balance and align aircraft structures. This chapter will introduce you to the principles and equipment required to perform both operations. Detailed instructions for balancing and alignment are contained in -3 technical orders.

6-1. Balancing of Aircraft Control Surfaces

Any time repairs on a control surface add or subtract weight fore or aft of the hinge centerline, the control surface must be rebalanced. Any control surface that is out of balance will not be stable or remain in a streamlined position during normal flight, such out-of-balance will cause the surface to flutter or buffet. For example, consider an aileron that is trailing edge heavy. It moves down when the wing deflects upward and moves up when the wing deflects downward. Such a condition can cause unexpected and violent maneuvers of the aircraft. In extreme cases, fluttering and buffeting may develop to a degree that could cause the aircraft to crash.

887. Differentiate between the two types of balancing conditions.

When rebalancing a control surface, you are concerned with both static and dynamic balance. If you statically balance a control surface correctly, it will be also correctly balanced dynamically.

Static Balance. Static balance is the tendency of an object subjected to forces of gravity to remain stationary only about an axis of rotation at its own center of gravity. The two ways in which a control surface may be out of static balance are underbalance and overbalance.

When a control surface is mounted on a balance stand, a downward travel of the trailing edge below the horizontal position indicates underbalance. Some manufacturers specify this condition with a plus (+) sign. Example A of figure 6-1 illustrates the underbalance condition of a control surface.

An upward movement of the trailing edge, above the horizontal position indicates overbalance. Example B of figure 6-1 illustrates the overbalance condition of a control surface. Some manufacturers specify this condition with a minus (-) sign. These signs (+ or -) indicate the need for more or less weight in the correct area to balance the control surface. Example C of figure 6-1 illustrates the balanced condition of a control surface.

A tail-heavy condition (static underbalance) causes undesirable flight performance and is usually not allowed. Better flight operations are gained by nose heaviness (static overbalance). Most aircraft manufacturers advocate the existence of nose heavy control surfaces.

Dynamic Balance. Dynamic balance is that condition wherein all forces acting on a body in motion are equally balanced so that the body does not vibrate while in motion. Dynamic balancing, as related to control surfaces, is the effort to maintain balance when the control surfaces move forward (as on the aircraft in flight). Dynamic balancing involves attaching weights in the correct places along the span of the surfaces. In most cases, the weights are added forward of hinge centerline.

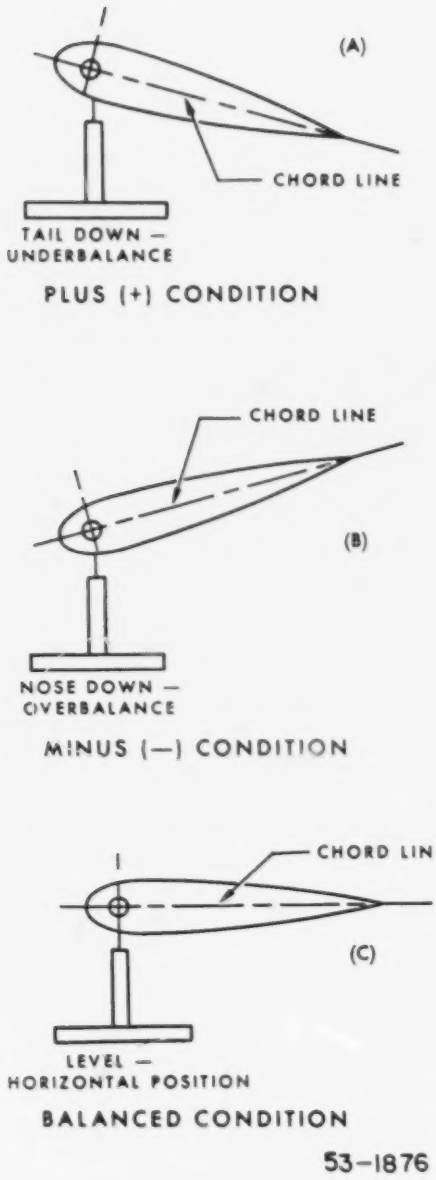


Figure 6-1. Control surface static balance.

Exercises (887):
In the space provided before each statement, indicate whether the statement refers to static or dynamic balancing by placing the letter "S" or "D".

____ 1. Condition wherein all forces acting on a body in motion are equal
____ 2. Involves adding weight forward of hinge centerline.
____ 3. An object remains stationary about an axis of rotation at its own center of gravity.
____ 4. Downward travel below the horizontal position indicates underbalanced condition.
____ 5. The use of plus (+) or minus (-) signs are not used to indicate balanced conditions.
____ 6. Better flight operations are gained by this type of overbalance condition.

888. Match given balancing terms with their proper definition.

In order to use balancing procedures and formulas, you must understand certain basic terms related to balancing. Such terms and symbols concerning balancing are as follows:

Weight Reaction (W_R). Weight reaction is the gross or calculated net weight used in the working of formulas to bring about a balanced condition in a control surface unit or an individual component. It is expressed and recorded to the nearest hundredth of a pound and is obtained with the chord line in a horizontal position. This position is illustrated in figure 6-2. Weight reaction is also defined as the force (in pounds) that is exerted upon the control surface causing it to move clockwise or counterclockwise. In figure 6-2, weight reaction is the pounds reading of the scale as the trailing edge of the control surface pushes down on the adjustable support and scale plate.

Control Surface Assembly Weight (W_s). Weight (W_s) is the *total* weight of a control surface assembly. For example, to determine the weight (W_s) of an inboard aileron, include the weight of the tab assembly, tap control push rod, nose seal, hinge fabric seal, and the hinge fabric seal (and retaining nut) as well as the weight of the inboard aileron assembly. In other words, W_s is the total weight.

Weight (W). In some aircraft, weight (W) is considered to be the weight of an individual *part* of a control surface unit. Examples of such parts are tabs, balance panel, aileron, etc.

Panel Weight (W_p). This is the actual weight of a complete balance panel including the aft hinge pin (and retainer) and the forward fabric seal.

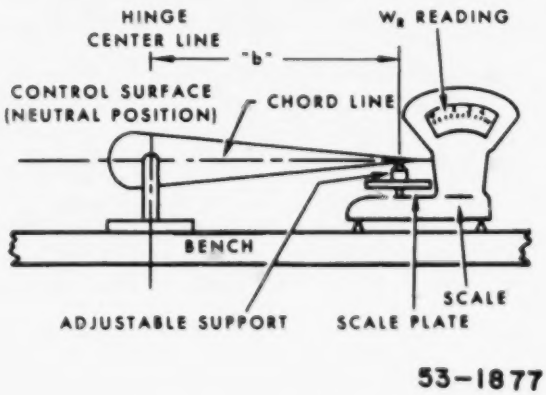


Figure 6-2. Weight reaction (WR).

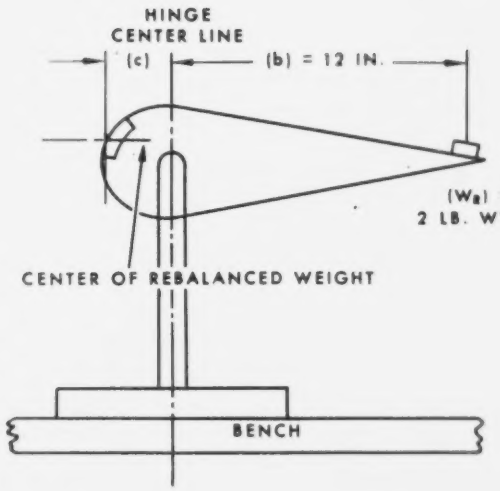


Figure 6-3. Effect of weight and distance.

Center of Gravity (cg). In rebalancing control surfaces the center of gravity is that point at which the surface can be balanced in any position. It is also the point of load concentration.

Hinge Centerline (HC_1). The hinge centerline is the axis about which the control surface rotates. This line is illustrated in figure 6-2.

Minus or Negative Sign (-). This sign was mentioned earlier. In rebalancing control surfaces, the minus sign is sometimes used to indicate an overbalance condition. A minus or negative sign preceding weight reaction (W_r) value means that the leading edge tends to move in a downward direction with the control surface in an overbalanced condition. This condition is normal on some aircraft and should exist on the control surfaces of these aircraft. The applicable technical orders list the acceptable limits for this overbalance condition.

Plus or Positive Sign (+). This sign was also mentioned earlier. It is sometimes used to indicate an underbalance condition. A plus or positive sign preceding weight reaction (W_r) value indicates that the trailing edge tends to move downward. This downward movement means that the control surface is in an underbalanced condition, and the unit must be rebalanced to the limits specified in the applicable technical order.

Symbol b. The symbol (or letter) b represents the measured distance from the hinge centerline (HC_1) to weight reaction (W_r) at the point of the adjustable support or weight. This distance is referred to as the moment arm b. The distance is measured, expressed, and its value recorded to the nearest hundredth of an inch. Moment arm b is illustrated in figures 6-2 and 6-3.

Symbol c. The symbol (or letter), c represents the measured distance from the hinge centerline to the center of the rebalance weight location. This distance is also measured and expressed and its value recorded to the nearest hundredth of an inch. Distance c is illustrated in figure 6-3, and is usually forward of the hinge centerline.

Moment (M). Moment is the term applied to the combination of force (weight) and distance. Moment (M) is defined as "the tendency of a force to cause rotation about a given axis." A simple example is that of a force being applied with a wrench to turn or tighten a nut. Moment is illustrated in figure 6-3 at $M = b \times W_r$. An example of the formula and the solution is given at the bottom of figure 6-3.

Exercises (888):
Match the balancing terms in column 2, to their proper definitions in column 1, by placing the letter of the balancing term in the space provided.

Column 1	*Column 2*
_____ 1. Actual weight a complete balance panel.	a. Weight (W)
_____ 2. Indicates underbalanced condition.	b. Weight reaction
_____ 3. Weight of an individual part of a control surface unit.	c. Hinge centerline
_____ 4. Distance from the hinge centerline weight reaction point.	d. control surface assembly weight
_____ 5. Total weight of control surface unit.	e. Panel weight
_____ 6. Distance from the hinge centerline to center of the rebalterline to center of the rebalance weight location.	f. Symbol b
_____ 7. Gross or calculated net weight used to bring about a balanced condition.	g. Symbol C
_____ 8. Combination of force and distance.	h. Moment (M)
_____ 9. Axis about which control surface rotates.	i. Plus or positive sign (+)
_____ 10. Indicates an overbalanced condition.	j. Minus or negative sign (-)

889. From information provided, determine the amount of weight required to develop a balanced condition on a repaired control surface.

Principles of Balancing. The principles that are essential in the balancing or rebalancing of the control surfaces are easy to understand if a simple comparison is used. For example, a child's seesaw that is out of balance may be compared to a control surface that does not have balance weights installed. Look carefully at the top half of figure 6-4. From this part of the illustration it is easy to see how a control surface is naturally tail (trailing edge) heavy.

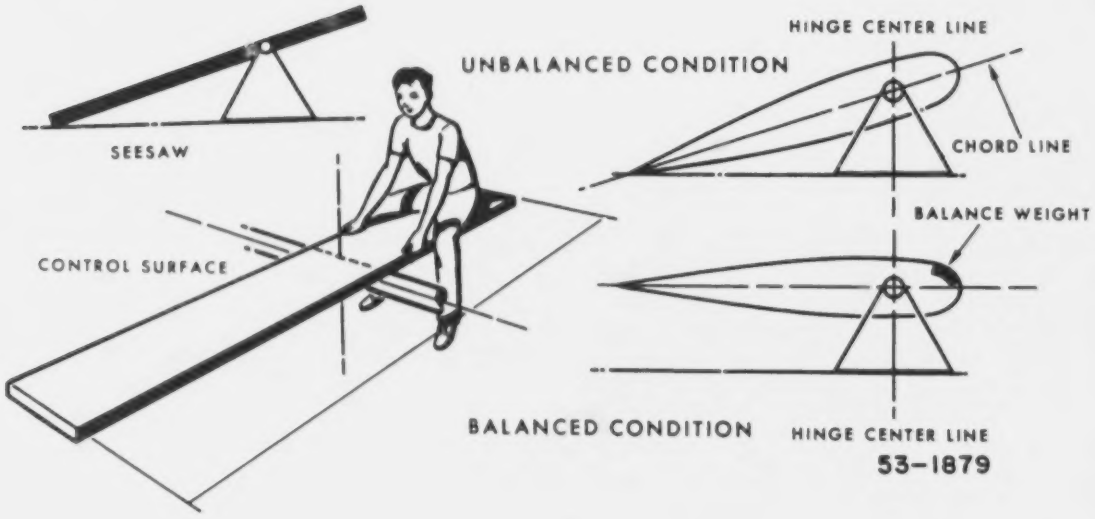


Figure 6-4. Unbalanced and balanced conditions.

As stated earlier, it is this undesirable condition of out-of-balance that causes a damaging flutter or buffeting of the aircraft. The out-of-balance condition must be corrected by adding weights either inside or on the leading edge of the tabs, to the horns on the inboard ailerons, or in the proper location on the balance panels. When the correct size weights are added at the correct places, the balanced condition exists and can be compared to the seesaw with a child sitting on the short end of the plank, as illustrated in the bottom portion of figure 6-4.

Moment of Force Computation. The effects of moments on control surfaces is illustrated by imagining two children of different weights seated in different positions on the seesaw. Figure 6-5 shows a seesaw with one 80-pound child seated 6 feet from the fulcrum. The weight of the child rotates the seesaw clockwise until the plank touches the ground. To bring the seesaw back to the level position (or balanced condition), mentally place another child on the opposite end of the seesaw. The child we imagine on the opposite end of the seesaw must be placed at a certain distance from the fulcrum and be of an exact weight in order to equalize the moment of the child on the left side of the seesaw.

Refer to figure 6-5 again. Suppose we place the child (that we added on the opposite end of the seesaw) 8 feet to the right of the fulcrum. A simple formula is used to determine the exact weight this child must have to balance the child on the left of the fulcrum and bring the seesaw back to the level condition. To produce a balanced condition of the seesaw (or control surface), the clockwise moment must equal the counterclockwise moment. Moment is found by multiplying weight times distance. Therefore, the formula to balance the seesaw is:

$$W_2 \times D = W_1 \times D_1$$

W_2 is the unknown weight of the second child. D_2 is the distance in feet the second child is seated from the fulcrum (8 feet). W_1 is the weight of the first child (80) pounds). D_1 is the distance in feet the first child is seated from the fulcrum (6 feet).

Finding the weight of the second child is now a matter of substituting and solving the formula as follows:

$$W_2 \times D_2 = W_1 \times D_1$$
$$W_2 \times 8 = 80 \text{ pounds} \times 6$$
$$W_2 = \frac{480 \text{ pounds}}{8}$$
$$W_2 = 60 \text{ pounds}$$

The weight of the second child must be 60 pounds. To prove the formula:

60 pounds x 8 feet = 80 pounds x 6 feet
480 pounds = 480 foot pounds

The seesaw is now in a balanced condition, since the clockwise moment around the fulcrum equals the counterclockwise moment. The same effect is obtained in a control surface by adding weights forward of the hinge centerline. Most of the repairs to control surfaces are aft of the hinge centerline and result in a trailing edge heavy condition. The correct rebalance weight must be calculated and installed in the appropriate place.

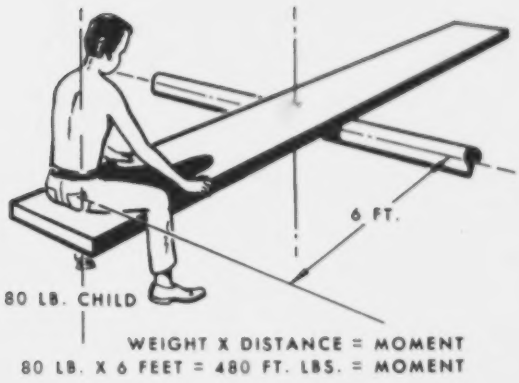


Figure 6-5. Moment.

Exercises (889):

1. If after a repair accomplished 15 inches to the rear of the hinge centerline, add 4 lbs to the control surface, how much weight must be added to the balance panel 6 inches forward of the hinge centerline?

2. If a TO specification required 25 pounds of weight to be added to a balance panel 15 inches forward of a hinge centerline, how much did the repair accomplished 30 inches to the rear of hinge centerline weight?

890. Distinguish among the four types of balancing methods by designating the most appropriate method to satisfy given characterizing statements.

Four methods of balancing (rebalancing) control surfaces are used by the various manufacturers of aircraft. The four methods are commonly called calculation method, scale method, trial weight (trial and error) method, and component method.

Calculation Method. The calculation method of balancing a control surface is directly related to the principles of balancing discussed earlier. It has one advantage over the other methods: it can be accomplished without removing the surface from the aircraft.

When you use the calculation method, you need to know the weight of the material removed from the repair area and the weight of the materials used to fabricate the repair. Subtract the weight removed from the weight added to get the net gain in weight added to the surface. Measure in inches the distance from the hinge centerline to the center of the repair area. NOTE: This distance (to the nearest hundredth of an inch) must be measured parallel to the chord line of the surface as illustrated in figure 6-6.

Next multiply this distance by the net weight of the repair. The answer will be inch-pounds. Consult the -3 technical order for the specific aircraft to determine any further actions. If the inch-pounds result of the calculations is within specified tolerances, consider the control surface balanced. If the result of the calculations is not within specified limits, the technical order will specify the needed weights, the material to use to fabricate the weights, the design for manufacturing the weights, and the installation locations for addition of the weights.

Scale Method. The scale method of balancing a control surface requires the use of a scale that is graduated in hundredths of a pound. A support stand and balancing jigs for the surface are also required. Figure 6-7 illustrates a control surface mounted for rebalancing purposes by the scale method. The scale method requires the removal of the control surface from the aircraft. *You must consult technical orders to determine removal procedures and parts or assemblies to be left attached to the surface.*

When the control surface is mounted on the stand, secure the trim tabs on the surface in the neutral position. Be sure the stand is level and located in an area free of air currents. The control surface must be free to rotate about the hinge points. Overbalance or underbalance condition is determined by the direction the trailing edge moves when the surface is suspended from its hinge points. Any excessive friction causes a false reaction as to the overbalance or underbalance of the surface.

Before you rebalance the control surface, place it in the neutral or level position. Use the bubble protractor set at the correct angle (as specified by the applicable technical order for the particular aircraft) to make sure the chord line is in the horizontal position. Since the adjustable support is located on the scale, you must account for this weight when you obtain the weight reactions. Account for this weight by either (1) weighing the adjustable support fixture separately and subtracting this weight from the total weight reaction or (2) setting the scales to zero after the adjustable support

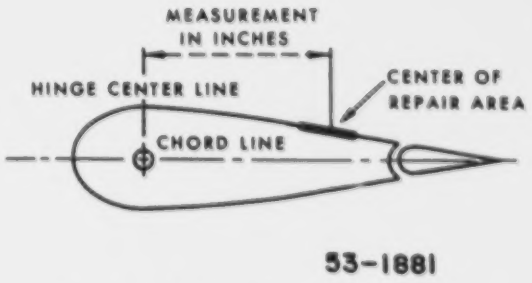


Figure 6-6. Calculation method of measurement.

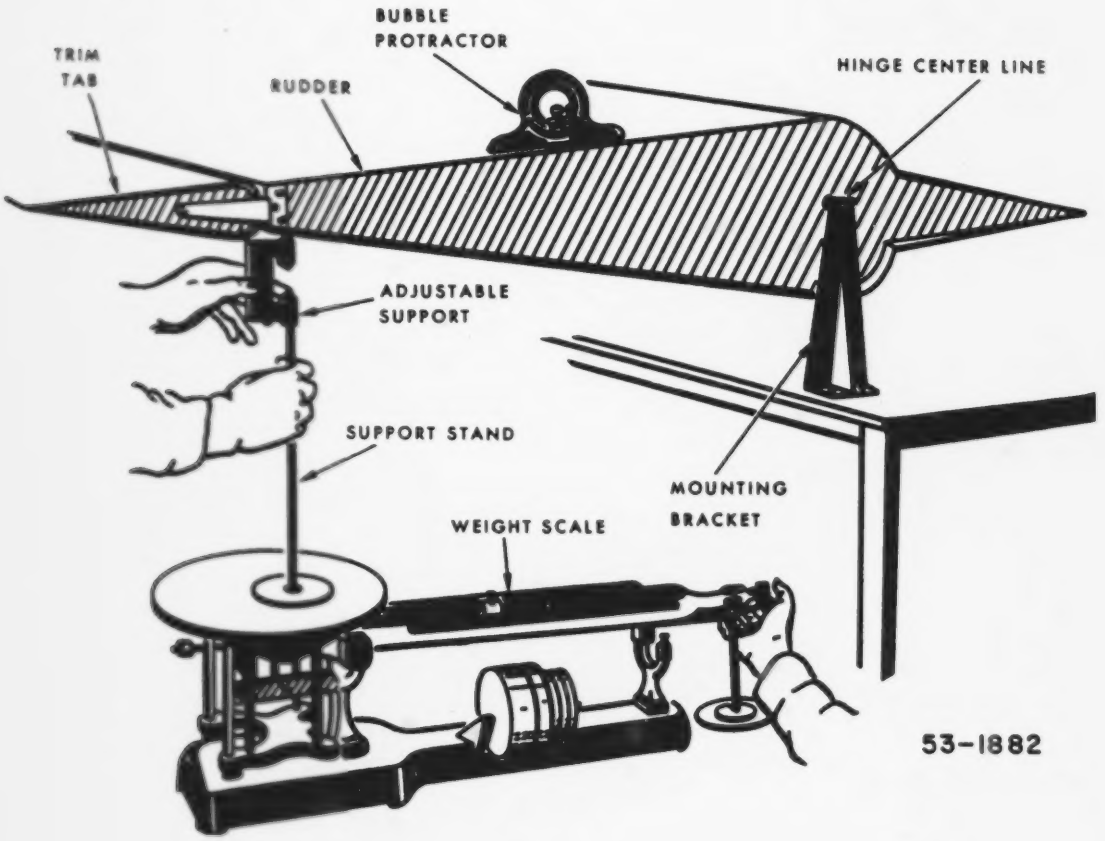


Figure 6-7. Balancing setup.

fixture has been mounted. Since most repairs to control surfaces are performed aft of the hinge centerline, the trailing edge will usually push down on the support stand and scale. NOTE: Consult the -3 technical order for the specific location of the support stand when you balance a control surface by the scale method.

The reading on the scale (to the nearest 1/100 inch) will be either a gross or a net weight reaction. You need to know the net weight reaction to use the table in the technical orders. To counteract the net W_r, add an equal amount of weight to the forward section of the control surface. *Consult the applicable tables of the -3 technical order for size, material, and location of weights needed to counteract the W_r.*]

Trial Weight Method. The trial weight method is a way of balancing a surface by using a known weight. The weight is positioned chordwise on the surface to bring the chord line level. The trial weight method consists of using a weight of known value in the rebalancing procedures. Steps to be followed in the use of this method are:

a. Place the control surface in a job or support stand. Check for friction free rotation about the hinge point.

b. Consult the technical order for the specific aircraft and control surface to determine the value of the weight to use.

c. From the applicable technical order table, determine the limits (along the chord line of the surface) between which the selected weight would have to be placed to balance the surface.

d. Obtain the selected weight. By locating it within the limits, determine whether the weights will balance the control surface.

e. If the above steps result in a balanced control surface, no further action is necessary.

f. If the control surface is not in a balanced condition as the result of the above procedures, additional weight must be added on the opposite side of the hinge centerline. Do this by selecting material and placing it in any available location. When enough of the selected material has been used to balance the surface, mark the location of the material and weigh the material. A weight should be locally manufactured (or obtained from supply, if available) and placed in the location previously marked. Installation can be accomplished by using whatever fastening devices are available.

Component Method. The component method of rebalancing is actually a combination of the scale and calculation methods. It consists of balancing each component by itself. Each component would maintain a specified amount (W_r) about the hinge centerline of the surface. Control surface installations made up of these components must be balanced within limits specified by technical orders. All components balanced by this method are considered to be interchangeable with other components on alternate complete units.

After the required rebalance weights have been calculated, they must be fabricated and installed properly. The rebalance weights may be made from fan steel, lead, arch bronze, corrosion resistant steel, or 4130 steel. The weight of these metals is useful in the fabrication of the rebalance weights and is as follows:

Lead	0.41-pound per cubic inch
Fan steel	0.602-pound per cubic inch
4130 steel	0.28-pound per cubic inch
Corrosion-resistant steel	0.31-pound per cubic inch

The -3 technical order for the specific aircraft usually gives the exact dimensions and material to use for local manufacture of weights needed to balance control surfaces. In many cases, the location and the amount of clearance needed determines the size and material of the weight.

Exercises (890):
Give the type of balancing method described in each statement.

1. Can be accomplished without removing the control surface from the aircraft.

2. All control surfaces balanced by this method are considered interchangeable.

3. This method of balancing involves positioning a known weight chordwise on the surface of the control surface.

4. Comparing two known weights to determine a net gain in weight.

5. This method is actually a combination of two balancing methods.

6-2. Optical Alignment

Optical alignment is generally accepted by industry and the Air Force as the latest and most accurate method for the testing alignment, and inspection of airframe structural members. For this reason, basic principles involved in using the various equipment associated with optical alignment are discussed in this section. For specific procedures for setup and operation of equipment, always consult the specific -3 TO.

891. Match basic terms related to the nature of light with their definitions or phrases that best describe them.

The exact nature of light is not definitely known; however, it is generally agreed that light is a form of energy that radiates from luminous objects and travels in waves (see fig. 6-8, sec. A). When these waves of light reach the eye, we are able to see. A luminous object is one that produces light waves; it shines by its own light. Examples of luminous objects are the sun, a lamp, candle, or white-hot metal. Non-luminous objects do not produce light themselves. When we see them, it is only because they are reflecting light from other sources. The moon is an example of a non-luminous object; we see it only because it reflects light that comes originally from the sun. Most of the things we see are non-luminous objects that are reflecting light from other sources. Regardless of whether an object is luminous or non-luminous, you are able to see it because light is coming from the object and entering our eyes.

To get a fuller understanding how light travels, let us take a look at some basic terms:

a. A *ray of light* is the path traced by any point on an advancing light wave. (See part B of fig. 6-8.)

b. A *bundle of rays* consists of a group of rays coming from a common point. (See part C of fig. 6-8.)

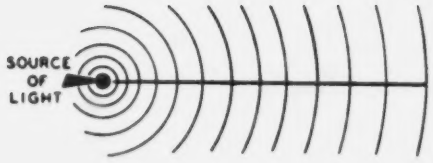
c. A *beam of light* is a group of bundles of rays put together; a flashlight is a common example. (See part D of fig. 6-8.)

d. A *medium* is any form of matter with which light waves may come in contact. The air, water, and glass are examples of such media.

(1) A *transparent medium* is one through which objects can be seen clearly and distinctly, such as a window pane.

(2) A *translucent medium* is one through which light will pass, but the light is so spread throughout the medium that objects behind it cannot be clearly and distinctly seen. A common example of a translucent medium is frosted glass.

A



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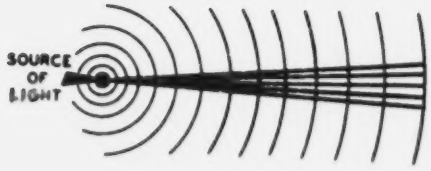

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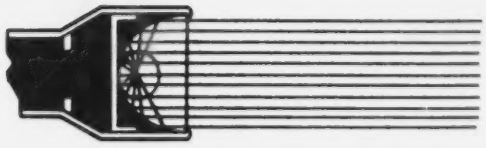

D

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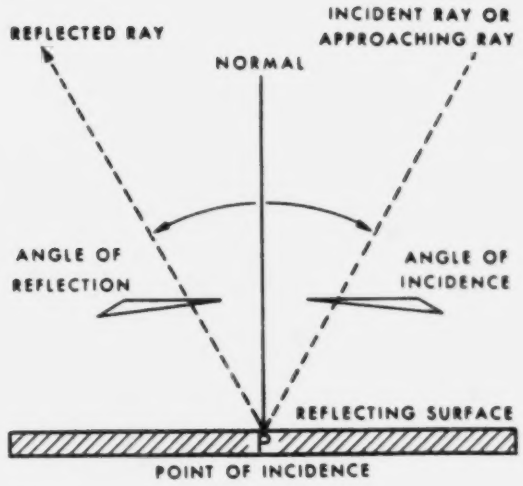
Figure 6-8. Principles of hour light travels.

(3) An *opaque medium* is one through which light cannot pass, such as a stone wall for instance.

Exercises (891):
Match basic light terms given in column 2 with the phrase in column 1 that is most appropriate for that term.

Column 1	*Column 2*
_____ 1. A flashlight is a common example of this term.	a. Ray of light b. Bundle of rays
_____ 2. A medium that spread light so much that objects behind it cannot be clearly seen.	c. Beam of light d. Medium e. Transparent medium
_____ 3. A group of rays coming from a common point.	f. Translucent medium g. Opaque medium
_____ 4. A medium that does not permit light to pass.	
_____ 5. Medium through which objects can be clearly seen.	
_____ 6. Path traced by any point on an advancing light wave.	
_____ 7. Matter with which light waves may come in contact.	

892. Cite the results when light strikes or enters a specific medium.



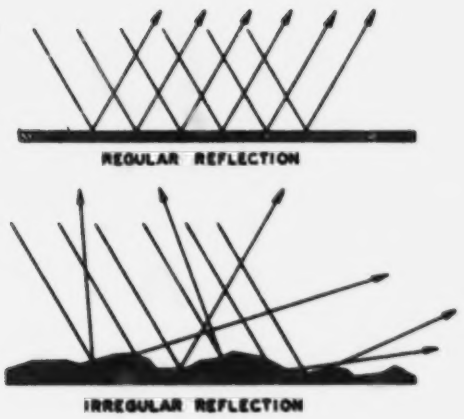


Figure 6-9. Reflection (laws and types).

Certain things happen to light rays when, while traveling through one medium, they strike another medium. If a light ray strikes a new medium and is sent back into the medium through which it came, it is said to be *reflected*. If the ray passes into a new medium and changes its course, it is said to be *refracted*.

Types of Reflection. In optical alignment you are concerned with two kinds of reflection: regular and irregular. *Regular reflection* occurs when a beam of light strikes a smooth surface, such as a flat and highly polished piece of metal, a mirror, or the surface of still water. The beam of light involved is reflected regularly and takes a definite course. Regular reflection can be compared to the bouncing of a perfectly spherical rubber ball on a smooth polished floor. If such a ball is dropped straight down, it will bounce back up along its original path. If it is thrown on the floor at an angle, it will bounce back up at the same angle in the *opposite direction*.

When the beam of light is reflected from a rough surface—such as a piece of paper, unpolished metal, or powdered glass—the result is an *irregular reflection*. The light involved would be scattered in all directions. Irregular reflection is comparable to bouncing a perfectly spherical rubber ball off a pile of rocks instead of a smoothly polished floor. Such a ball would rebound in any direction, depending upon where and how it hits.

Reflected light rays obey the following laws of reflection, whether they strike a smooth or a rough surface, as shown in figure 6-9, (lower illustration).

The *incident ray*, the *normal*, and the *reflected ray* are all in the same plane. The *angles of incidence* and the angles of reflection are equal, (see upper illustration in fig. 6-9).

The most commonly known surface used for regular reflection is the mirror. When a person looks into a mirror, he sees a reversed image of himself that appears to be behind the mirror. To the observer's eye, the image of the object appears to be behind the mirror, because this is the direction from which light rays are coming after they have been reflected. Also, the image appears to be at a distance behind the mirror, equal to the distance of the object from the front of the mirror.

Refraction. When light passes from one medium into another medium, its rays are bent or refracted. Let us use a familiar analogy to illustrate this process. Suppose that a column of airmen is marching eight abreast across a hard, dry drill field when suddenly it encounters a diagonal strip of sand. Naturally, airmen cannot march as fast in the sand as they can on hard, dry ground. Hence, when the first airmen in the column reach the sand, they slow up, while the other airmen continue to march at their normal step. The other airmen finally slow up when they reach the sand; but, before all the men reach the sand, the column is given a command, changing direction. The effect is a bend in the line of the march.

The same thing occurs to a beam of light when it enters a new medium of different *density*. Light travels more slowly in water, glass, or other transparent media than it does in air. Light is also bent when it travels from the air into one of these media or from one of these media into the air. The direction in which the light is bent depends upon the density of the medium into which it passes. For example, when light passes from air into a dense medium, such as water, it is re-

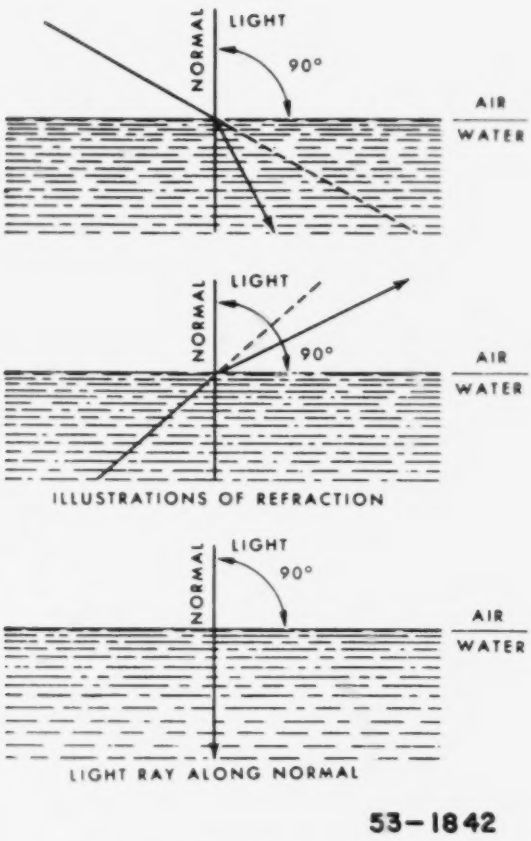


Figure 6-10. Light ray refraction.

fracted toward the normal (perpendicular). On the other hand, when light passes from water into air, it is reflected away from the normal, as illustrated in figure 6-10. Of course, if the light enters the water on a path that is perpendicular to the surface of the water—in other words, along the normal—it is not refracted but continues in the same direction. (See fig. 6-10.)

Refraction can be used to change the direction of light. This change is brought about by changing the position of the glass or the shape of the glass. If a ray of light passes obliquely through a plate of glass with parallel surfaces, it will emerge in a direction parallel to the direction it entered. This is true because a ray of light entering a piece of glass will be refracted a certain amount toward the perpendicular. When the light ray leaves the glass, it is refracted by that same amount toward the perpendicular. Then the light ray leaves the glass, it is refracted by that same amount away from the perpendicular, as illustrated in figure 6-11.

Light rays entering a body of glass are refracted toward the thick part of the glass. Therefore, curved glass will either converge or spread light that passes through it. Figure 6-12 illustrates how irregular-shaped glass changes the direction of the light.

Exercises (892):

1. What happens when a beam of light strikes a polished piece of metal?

2. If a beam of light enters a medium at a 45° angle, what effect has this on the direction of the beam of light?

3. When a beam of light strikes a piece of paper, what type of reflection occurs?

4. Light striking a mirror produces what type of reflection?

5. When light passes from water to air, in what direction is the light refracted?

6. What happens to light when it passes from one medium to another?

893. From a list of statements about optical elements, identify the true statements and explain why the others are not correct.

All optical instruments are made up of one or more optical elements that are combined to produce a desired effect. The most common optical elements used are mirrors, prisms, and lenses. Therefore, to understand optical instruments, it helps to know what these optical elements do to rays of light.

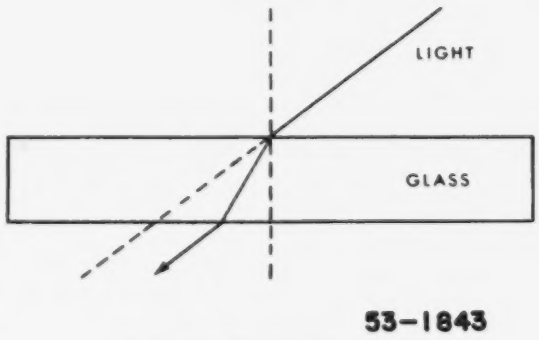


Figure 6-11. Refraction in plate glass.

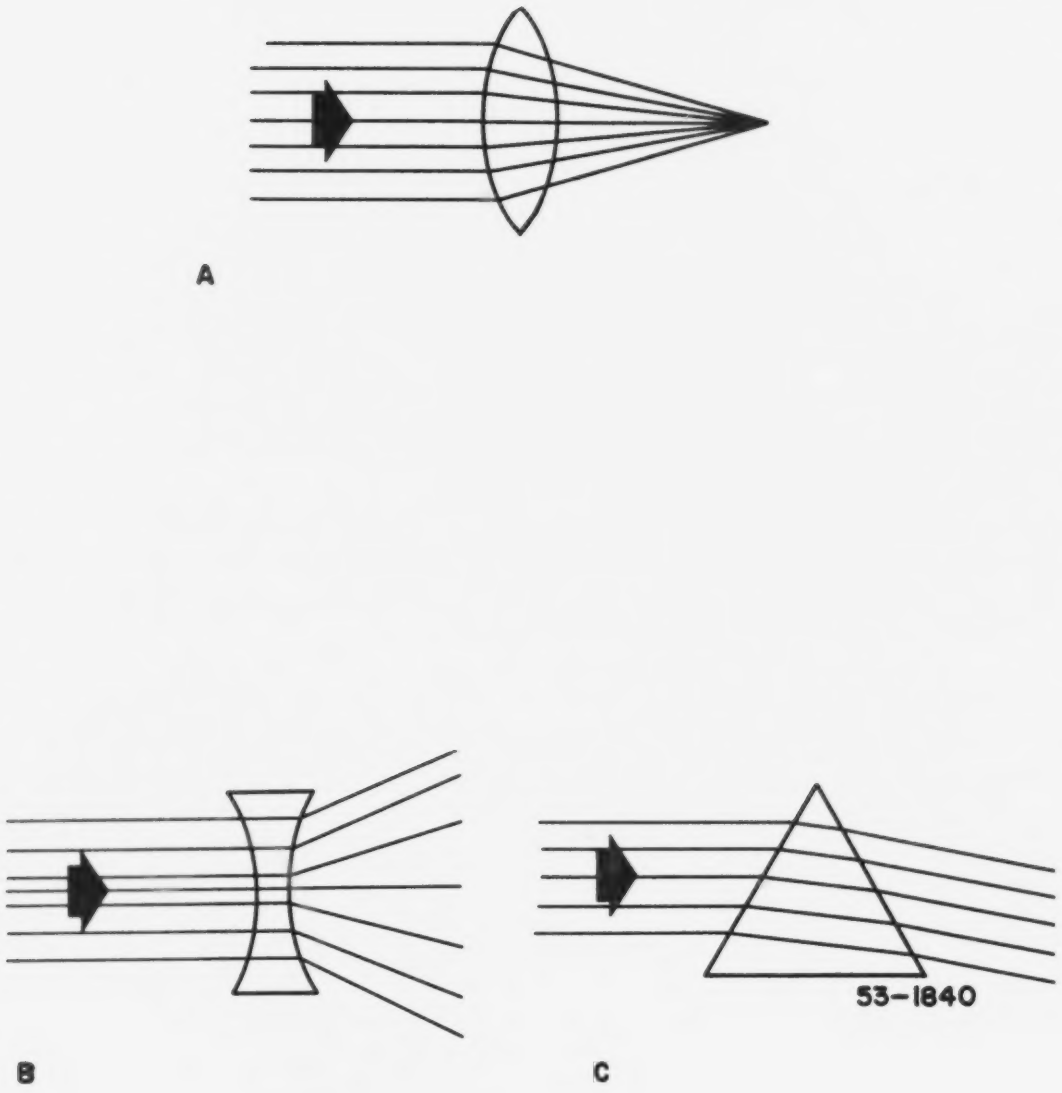
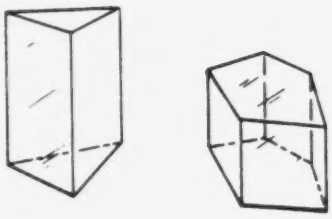


Figure 6-12. Effects of irregular-shaped glass.

Prisms. In optical instruments, it is often necessary either to change the direction or to shift the position of the light rays. This is accomplished by using bodies of glass known as *prisms*. (See fig. 6-13, part A.) Light entering a prism can be either reflected or refracted. The angle at which the light enters the prism determines whether reflections or refraction will take place. The critical angle is the transition point between reflection and refraction, as shown in figure 6-13, part B. If light rays enter a prism *at* the critical angle, they are reflected and refracted. If light rays enter the prism *within* the critical angle, they are refracted through the prism. If they strike the prism *beyond* the critical angle, they are reflected out of the prism.

A *pentaprism* is a five-sided prism used to change the direction of light rays 90° from their original path. The image comes out of the pentaprism in the position that it entered. Reflecting surfaces of the pentaprism are coated with a reflecting agent; consequently, rays that strike the surface within the critical angle will be reflected out of the prism.

Lense. A *lens* may be thought of as a group of prisms fitted together. It is a piece of transparent refracting substance whose opposite surfaces may both be curved or one of which may be curved and the other one flat, as shown in figure 6-14.



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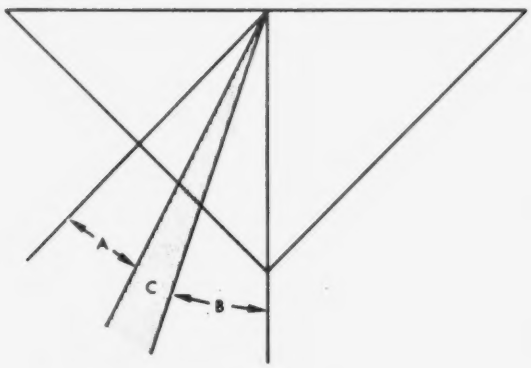

A. BEYOND CRITICAL ANGLE
(LIGHT REFLECTED)

C. WITHIN CRITICAL ANGLE
(LIGHT REFRACTED)

B. CRITICAL ANGLE

B

53-1841

Figure 6-13. Prism.

All lenses refract light. Some bring light rays to a point; others spread the rays. The shape of the lens determines whether light rays striking the surface will be converged or spread out. For example, the *convex* lens may cause a large number of light rays to converge due to the refraction of the rays toward the thick part of the lens. But regardless of the type of prism or lens used, the light rays are always refracted toward the thickest part.

The *focal plane* is a plane at which light rays passing through a lens may come together and form the image of an object, as shown in figure 6-15. The location of the focal plane depends upon the location of the object. As the object moves further away from the lens, the focal plane moves closer to the lens.

The focal plane of a camera is the film. The lens can be moved forward to adjust the focal length (distance between lens and focal plane) as the object moves closer to the lens. The lens system of the camera must be properly focused to obtain a clear picture. The camera raises the convex lens to converge light rays and form an inverted image of the object. The objective lens of a telescope works in the same way. A lens in the telescope must be moved backward and forward to bring the image of an object into focus.

Exercises (893):
If one of the following statements is correct, mark it true; if it is false, correct it.

___1. All lenses reflect light.

___2. Light direction is changed through the use of prisms.

___3. If a light ray enters a prism at the critical angle, it is either reflected or refracted.

___4. The location of the focal plane depends upon the distance the object is from the lens.

___5. Convex lens may cause light rays to converge.

___6. Light rays are always reflected toward the thickest part of a prism.

___7. Light rays entering a pentaprism come out in the position they entered.

___8. The critical angle is the transition point between reflection and refraction.

894. Match terms concerning the features and types of telescopes with their definitions or phrases that best describe them.

Figure 6-14. Lenses.

One of the basic units used for the alignment of aircraft and jig construction is the *telescope*, as shown in figure 6-16. The tilting level and surveyor's transit employ its use.

Features and Nomenclature of Telescopes. You can gain a better understanding of optical instruments by studying the following paragraphs that discuss the basic features and nomenclature of the telescope, as well as the types of telescopes commonly in use.

- *Objective lens.* Rays of light coming from an object within the field of view of the telescope are caught by the *objective lens*. These rays add up to form an inverted image of the object on the focal plane.
- *Focusing lens.* The *focusing lens* is used to bring the light rays into focus by forming an image of the object on the plane of the crosshairs. Adjustment of the focusing lens is made by rotating the focusing knob as necessary. The focusing lens is located in a draw tube (cylinder), which is moved forward and backward inside the barrel of the telescope by means of a gear arrangement attached to the focusing knob. This is known as an *internal focusing system*. When the focusing lens is properly adjusted, the image on the plane of the crosshair is small and always inverted.
- *Crosshair reticle (ring).* The *crosshair reticle* may be compared to a motion picture screen upon which an

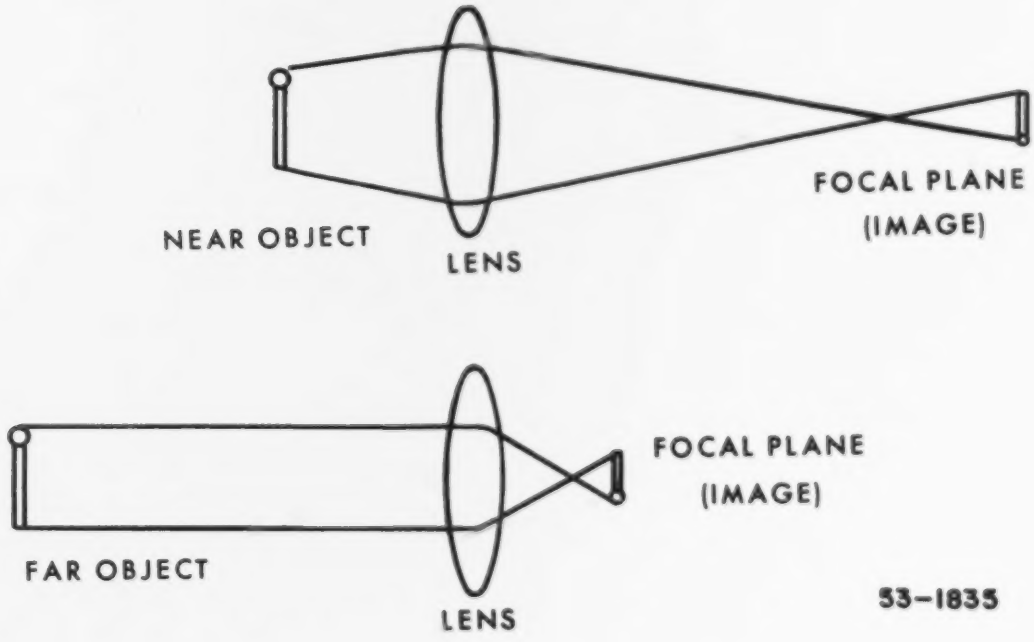

Figure 6-15. Examples of focal planes.

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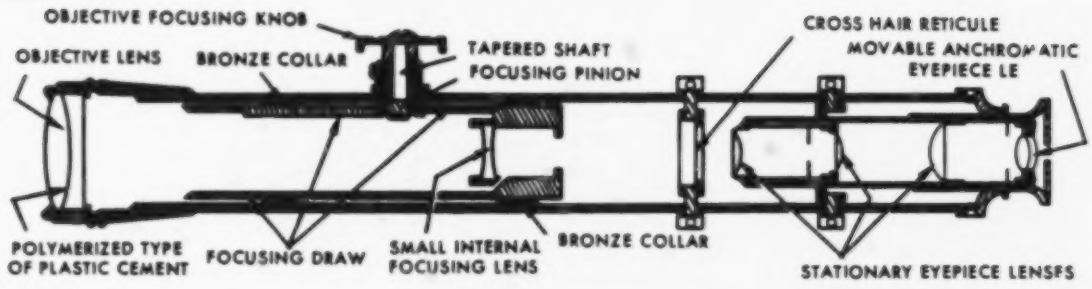

Figure 6-16. Types of telescopes.

image is projected. This screen (plane) is a glass or plastic disc containing lines that locate the exact center of the plane.

• *Eyepiece lens unit.* The telescope contains an *eyepiece lens unit* to make the image larger and more easily seen. In some telescopes, the eyepiece lens unit is designed to make the image appear in a normal right-side-up position, while other telescopes have eyepieces that leave the image inverted.

• *Mechanical and optical axes.* Two other important parts of most telescopes are their *mechanical* and *optical axes.* The mechanical axis of a telescope is an imaginary straight line that passes through the center of the telescope barrel. The optical axis is an imaginary straight line that passes through the center of the lenses of the telescope. The center of the crosshairs will lie on the optical axis when the telescope is properly adjusted.

Types of Telescopes. A telescope whose eyepiece leaves the image inverted is known as a *celestial telescope*; this is the type generally used by astronomers, as shown in figure 6-17. An inverted image, as seen by the celestial telescope, is one which is upside down and on which the right side of the object appears to the left.

A telescope designed to erect the image of an object is called a *terrestrial* (land) *telescope*, as shown in figure 6-18. An *erect image* is one in which the image is in the same position as the object being viewed, with the top side up and the right side on the right.

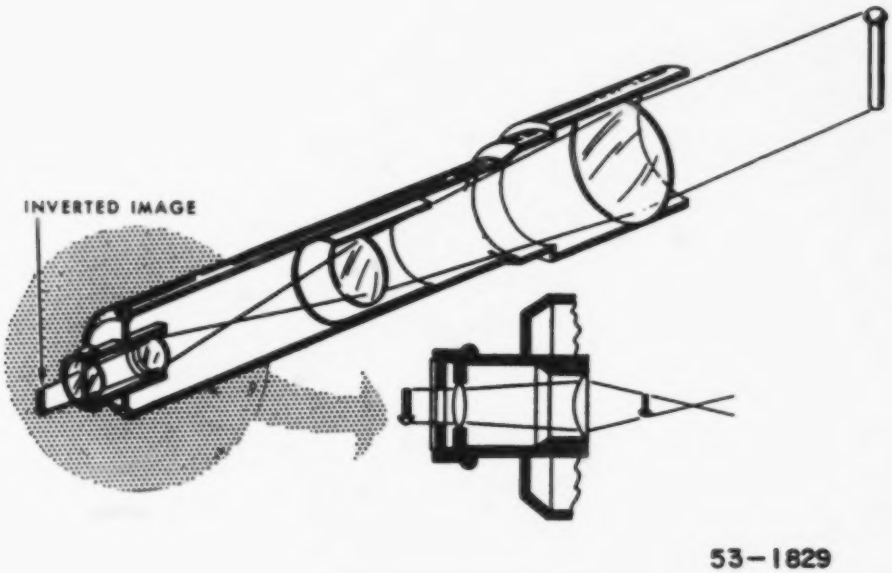

Figure 6-17. Celestial telescope.

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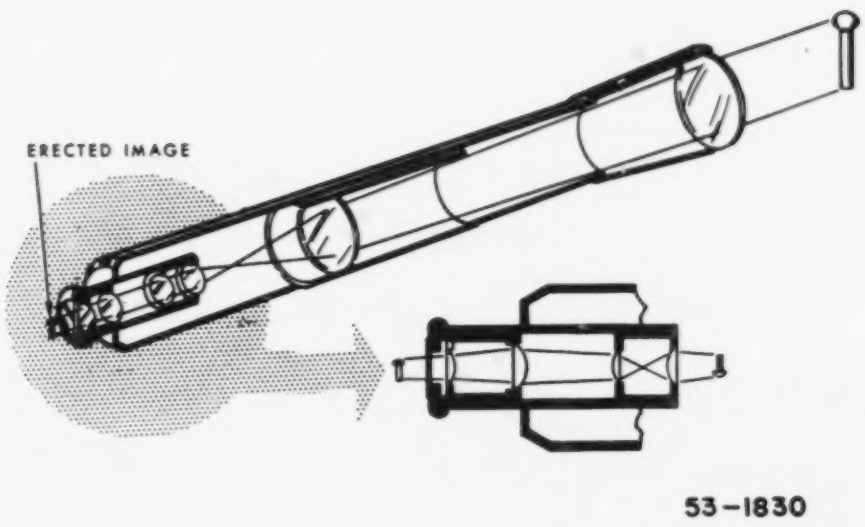

Figure 6-18. Terrestrial telescope.

Exercises (894):
Match the terms in column 2 with the phrase in column 1 that is most appropriate for that term. Some terms may be used more than once.

Column 1	*Column 2*
___ 1. Screen which locates the exact center of a plane.	a. Objective lens
___ 2. Makes object larger and more easily seen.	b. Focusing lens
___ 3. Form image of an object on the crosshairs.	c. Mechanical axis
___ 4. Form image of an object on the focal plane.	d. Optical axis
___ 5. First lenses to form inverted image.	e. Celestial telescope
___ 6. Straight line through barrel of telescope.	f. Terrestrial telescope
___ 7. Straight line through center of lenses.	g. Crosshair reticle
___ 8. Telescope that produces an inverted image.	h. Eyepiece lens
___ 9. Located in a draw tube inside of telescope.	
___ 10. Telescope that produces an erect image.	

895. Indicate whether given statements correctly reflects terminology associated with the principles of telescope operation; if a statement is invalid, correct it.

Much could be said about the principles of operation of the telescope. However, we restrict our discussion to only those principles that seem particularly applicable to an airframe repair specialist.

Parallax. The focusing lens inside the telescope forms an image of the object being sighted. This formed image should be in the same plane as the crosshairs. If the image is not in the same plane as the crosshairs, the crosshairs will appear to move across the image when the eye is moved. This is known as *parallax*, as illustrated in example A of figure 6-19.

Whenever a reading is taken that involves adjustment of focusing, parallax must be checked for and eliminated. Parallax may be eliminated by adjusting the eye piece and objective focusing knob until the crosshairs and image appear to give the same results when viewed from any position of the eye, as shown in example B of figure 6-19.

Magnification. The rated power of a telescope (such as 28X, 30X, 42X, etc.) is the greatest *magnification* that can be obtained. This magnification occurs only when the telescope is at its infinite focus.

Resolving Power. The *resolving power* of an instrument is the capacity of its lens system to show detail. The resolving power is determined by the instrument's capacity to render a clear and distinct image of narrow separations, such as those encountered on scale graduations. Resolving power is measured by the smallest angular distance between two points that can be distinguished as separate points.

Definition. *Definition* is a general term used to express the results obtained with a telescope. The better the definition, the better the image of an object can be seen through a telescope. The definition of a particular telescope can be effectively appraised, first by viewing an object through the telescope being checked; then by viewing the same object through a telescope with which you are familiar; and finally, by comparing the images of the two.

Pointing Accuracy. *Pointing accuracy* is the accuracy at which a target can be adjusted into a line of

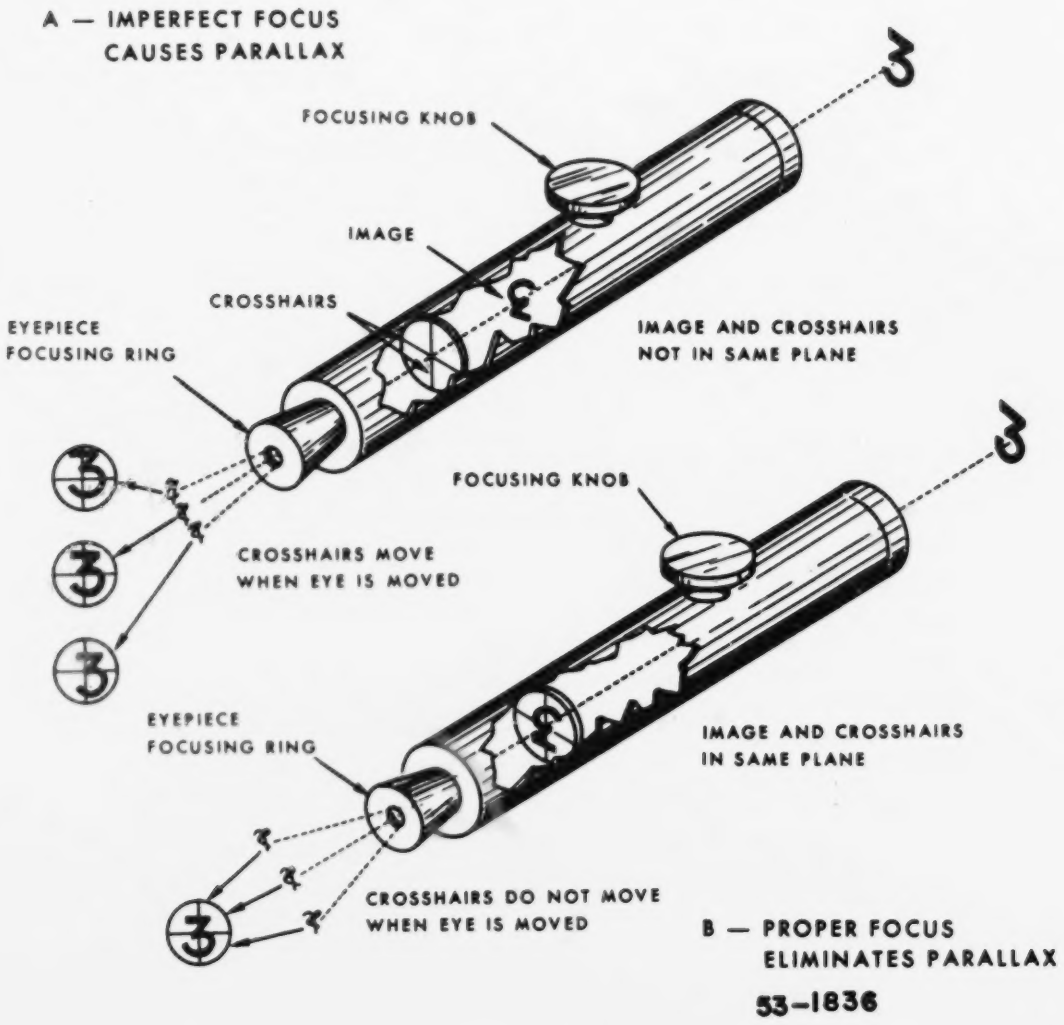

Figure 6-19. Parallax.

sight. It is relative to magnification but depends chiefly on definition. Crosshair arrangement and conformance of target or scale design will have a bearing on pointing accuracy. The accuracy with which a reading can be repeated from the same setting of the telescope and target determines the pointing accuracy of the instrument. Remember that power alone does not classify the accuracy of a telescope. A combination of proper magnification, ultimate resolution, and clear definition are required for a good optical system.

Exercises (895):
Correct any statement that incorrectly reflects the meaning of terminology related to the principles of telescope operation.

1. Parallax occurs only when the telescope is at its infinite focus.
2. Definition is a general term used to express the resolving power obtained with a telescope.
3. Pointing accuracy depends mainly on definition.
4. Movement of the crosshairs across an image indicates a parallax condition.
5. The resolving powers is the capacity of a lens system to show magnification.

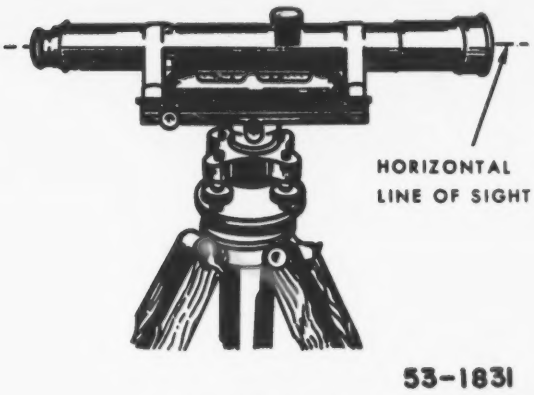

Figure 6-20. Sight level.

896. Specify whether given functions required when aligning aircraft structure can be accomplished by using a sight level.

Sight Level. The *sight level*, shown in figure 6-20, is an instrument that embodies the principles of optics. There are several types of sight levels, but the basic principle of each type is relatively the same as that of each of the other types. Each type consists of a telescope that can be set up so that its optical axis will rotate in a horizontal plane about the vertical axis of the instrument when the instrument is level. The term "sight level" is derived from the fact that sight levels have a telescope through which objects are sighted, which distinguishes them from the machinist's level.

The term "line of sight," when associated with sight levels and other optical instruments, refers to the specific line of sight (essentially the path of a single ray of light) when the instrument is in a fixed position. This line of sight should not be confused with the horizontal and vertical planes that can be established by the sight levels and the transit, respectively. Since sight levels are used to establish a horizontal plane through 360° of arc, the horizontal plane is generated when the telescope of the sight level is rotated about its vertical axis.

Exercises (896):
At the end of functional statement, indicate whether it can be accomplished using a sight level. Use the words "yes" or "no."

1. Establish horizontal planes.

2. Establish vertical planes.

3. Rotate about its horizontal axis.

4. Rotate about its vertical axis.

897. Cite uses or operational procedures for a transit and, individual components of a transit.

Transit. The *transit*, shown in figure 6-21, is a basic instrument used extensively by construction engineers and surveyors. In their work, it is used in measuring horizontal and vertical angles and differences in elevations and distances, prolonging straight lines, spirit leveling, taking compass bearings, etc. The use of transit is generally much less varied in the alignment of aircraft, where it is used to establish the vertical centerline of the fuselage and to measure angles, such as the attitude of the vertical fin and the sweepback angle of the wings. The transit may also be used for establishing horizontal lines of sight if a tilting level is not available.

A transit consists of a telescope mounted 90° to a horizontal axis that is supported by a trunnion framework. The entire framework, consisting of a base and two vertical standards, is mounted on a vertical axis. Thus, the instrument can be rotated about the vertical axis to sweep a vertical plane. This arrangement of the vertical and horizontal axis makes it possible to reverse the instrument and repeat a setting or *prove* a reading.

The term "transit the telescope" refers to the act of rotating the telescope about the horizontal axis. The term "rotate instrument" refers to the act of rotating the standards and telescope about the vertical axis. The term "reverse instrument" refers to rotating the telescope and standards 180° about the vertical axis and transmiting the telescope 180° about the horizontal axis.

Nomenclature. Parts common to all transits and sight levels are the eyepiece focusing ring, the objective focusing knob, and the leveling screws. Figure 6-21 illustrates these and other parts of a transit. You should study the nomenclature carefully and become thoroughly familiar with each functional part of the transit.

- *Eyepiece focusing ring.* The purpose of the focusing ring is to compensate for variations in eyesight of different observers, enabling each observer to bring the crosshairs of the instrument into focus.
- *Leveling screws.* Leveling screws are used to plumb the vertical axis. Some instruments are equipped with three leveling screws, some with four.
- *Vertical clamping screws.* When the vertical clamping screw is released, the telescope can be rotated in either direction about the horizontal axis of

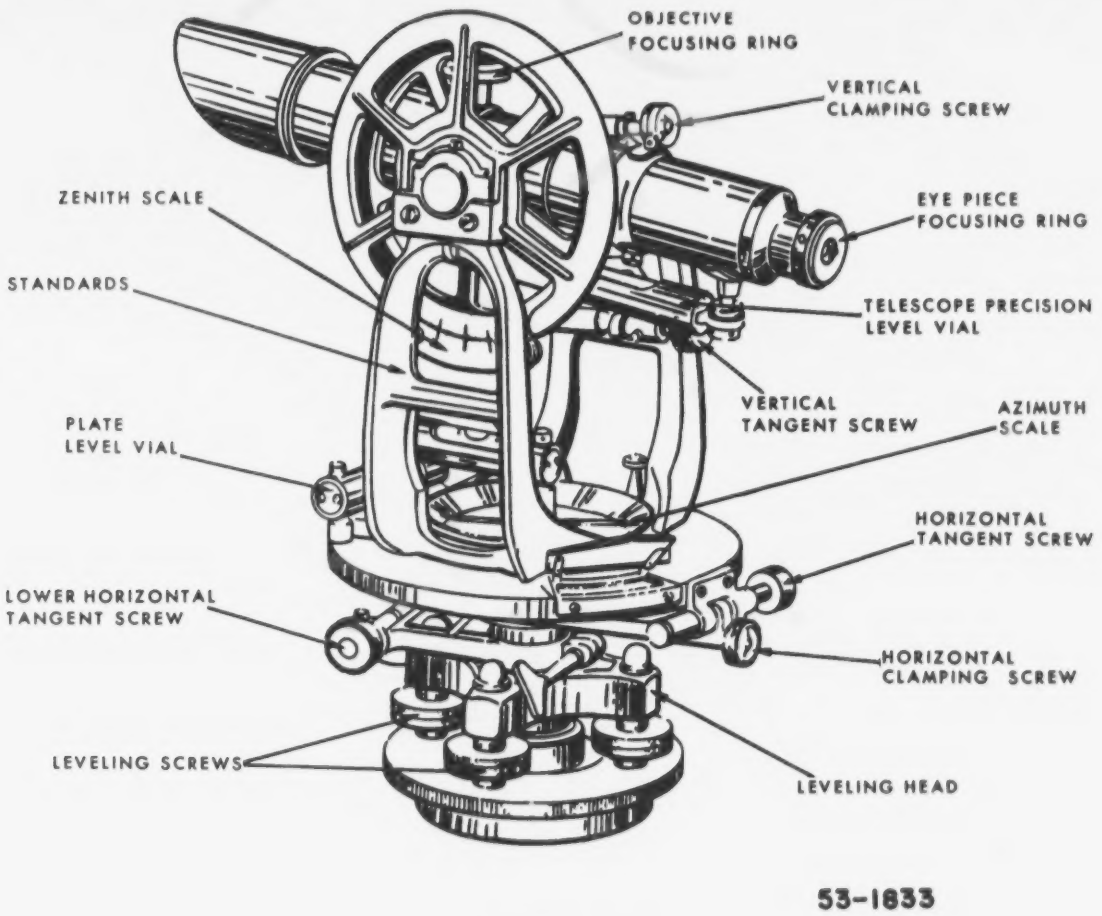

Figure 6-21. Transit.

the instrument. To lock the vertical vernier (zenith) scale in any position, tighten the vertical clamping screw snugly.

• *Vertical tangent screw.* After the vertical clamping screw has been tightened snugly, the vertical tangent screw is used for any slight movement of the telescope in either direction necessary to attain alignment with the target.

• *Horizontal clamping screws.* When either of these horizontal screws is released, the telescope can be rotated in either direction about the vertical axis of the instrument. The upper horizontal clamping screw controls the inner spindle and is used to lock the horizontal vernier (azimuth) scale to any desired reading. The lower horizontal screw controls the outer spindle and, when tightened, prevent the instrument from rotating.

• *Horizontal tangent screws.* After the lower horizontal clamping screw has been tightened snugly, the lower horizontal tangent screw is used for any slight rotation of the standards in either direction about the vertical axis to attain alignment with the target. The upper horizontal tangent screw aids in the precise setting of the horizontal vernier scale.

• *Level vials.* Level vials are mounted on the transit to aid in rough and precision leveling of the instrument. The plate level vials and the telescope precision level vial differ in sensitivity. One plate level vial is mounted on the upper plate of the instrument parallel to the horizontal axis of the telescope. Another is mounted on one of the standards perpendicular to the horizontal axis of the telescope. The plate level vials are observed when rough-leveling the instrument. The telescope precision level vial is mounted directly onto the telescope, parallel to the optical axis. Coupled with its greater sensitivity, the telescope precision level vial gains a mechanical advantage over the plate level vials by reason of its length and points of suspension.

Exercises (897):

1. When would you use a transit for establishing horizontal lines of sight?

2. When it is necessary to "rotate the instrument," what would you be doing with the transit?

3. How is the transit released to rotate about its horizontal axis?

4. How is precise setting of the horizontal vernier scale obtained?

5. How is slight movement of the telescope about its horizontal axis accomplished?

898. Given an additional function required when using a tilting dumpy level, indicate the appropriate procedure to follow.

Tilting Dumpy Level. The tilting dumpy level, illustrated in figure 6-22, is a type of sight level having a 30-power (30X) terrestrial telescope with a minimum focus of 5 feet. It is discussed separately here because of its peculiar importance. When used with the optical micrometer as an attachment, the instrument will maintain an accuracy of ±0.003-inch at 20 feet and ±0.10-inch at 60 feet. Along with the accuracy, we will discuss nomenclature and setting up the instrument.

Advantage and Operation. The outstanding advantage of the tilting level is that with it, the telescope is pivoted about a horizontal axis that intersects the vertical axis of the instrument. Because of this, when you use this level, the height of the telescope axle above the ground does not change as the telescope is rotated, even if the center spindle is not vertical. Since the height of the telescope axle is not fixed and does not change when the telescope is precisely leveled, the horizontal plane swept by the precisely leveled line of sight is always the same distance above the ground. Figure 6-22 shows both the side views of the tilting dumpy level.

Nomenclature. You must learn the name (as shown in fig. 6-22) and function of each part of this instrument before you can become skilled in its use.

- *Clamp screw.* The clamp screw is used to lock the telescope in any position when the clamp's screw is tightened. When this screw is released, the telescope can be rotated in either direction about the vertical axis of the instrument.
- *Tangent screw.* This is a fine-adjustment screw for rotating the telescope clockwise or counterclockwise about the vertical axis of the instrument after the clamp screw is tightened. By using this fine adjustment, the vertical crosshair of the instrument can be lined up with the target.
- *Eyepiece focusing ring.* The purpose of the focusing ring is to compensate for variations in eyesight of different observers, enabling each observer to bring the crosshairs of the instrument into focus.
- *Objective focusing knob.* This focusing knob is used to bring the image of the target into focus on the plane of the crosshairs as observed through the eyepiece. It is rotated to compensate for variations in distance between the telescopes and the various targets observed.
- *Leveling screw.* Leveling screws are used to plumb the vertical axis. Some tilting levels are equipped with three leveling screws; some, with four.
- *Circular level vial.* The circular level vial bubble can be centered by adjusting the leveling screws to plumb the vertical axis of the instrument.
- *Tilting screw.* The tilting screw allows the user to raise or lower the eyepiece end of the telescope as necessary to center the level bubble. It is used for making minor adjustments each time a reading is taken.
- *Split bubble.* The split bubble is a telescope precision level vial viewed through a series of prisms mounted inside the instrument. The bubble is observed through an eyepiece or viewing window and is illuminated by a mirror that can be adjusted by turning the attached knob. A white surface on the reverse side of the mirror is used to prevent glare when an excessive amount of light is present.

Exercises (898):
Below each statement, related to using a tilting dumpy level, write in the procedure required to accomplish the function called for in the statement.

1. Centering of circular level vial bubble.

2. Maintain an accuracy of ±0.003 of an inch at 20 feet.

3. Rotate the instrument about its vertical axis.

4. Make minor adjustment about the instruments vertical axis.

5. Center the level bubble of the instrument.

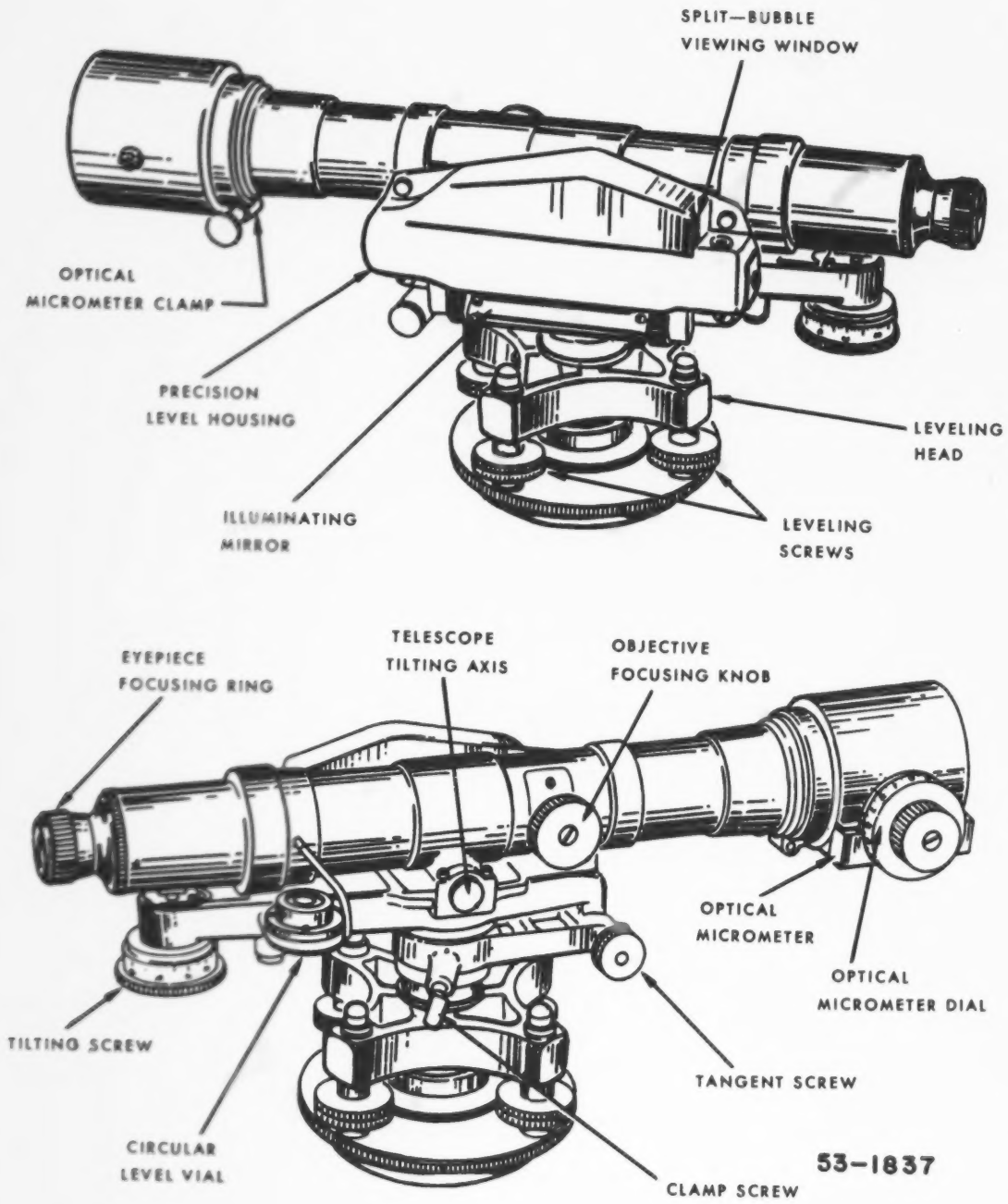

Figure 6-22. Tilting dumpy level.

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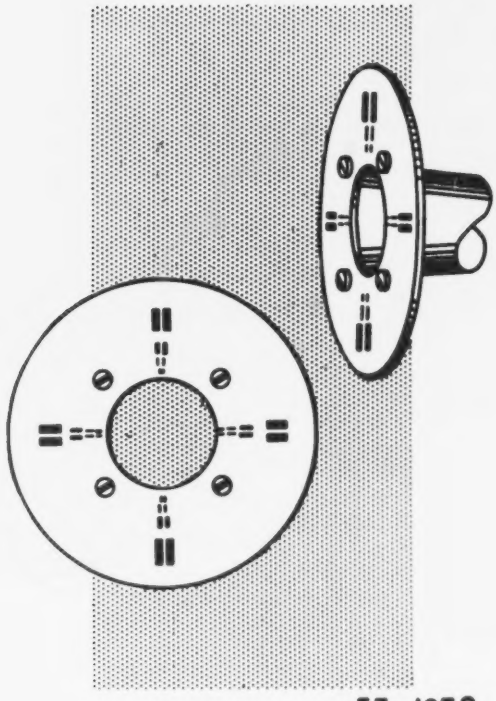

Figure 6-23. Auto reflection target.

899. Cite operating principles and procedures for auto-reflection equipment.

Auto-Reflection Target. In the past, the transit was used to establish reference planes that were perpendicular to the line of sight. This was an extremely difficult and time-consuming procedure. Recently, improved methods based on auto-reflection have been devised to assist in the establishment of perpendicular planes. Auto-reflection is the act of looking through a telescope at a mirror and viewing an image of a target that is attached to the telescope. Figure 6-23 shows a typical auto-reflection target that can be attached to a telescope. The four sets of dash marks (at 90° to each other) on the target make it possible to center the target image on the crosshairs of the telescope. The dash marks nearest the center of the target are 0.010-inch apart, which helps the observer to center the target image on the crosshairs.

Auto-reflection is based on the simple principles of reflection of light from a flat mirror. It is similar to what takes place when a person holds a mirror in front of his face and looks into it. If he turns or tilts the mirror far enough, the person will not be able to see himself. This is true because the light reflected from his face strikes the mirror and obeys the law of reflection that states that the angle of reflection is equal to the angle of incidence.

If a person moves the mirror back into a position where it is perpendicular with his line of sight, he will then be able to see himself. Light rays that strike a mirror on a path perpendicular to the mirror return to the same path from which they come. The same principles apply if a target is mounted on the end of a telescope and a mirror is viewed. If the mirror is tilted far enough from the line of sight, either vertically or horizontally, the target cannot be seen in the mirror.

Suppose, however, that the mirror is adjusted so that it is exactly perpendicular to the line of sight. Light rays approaching the target along the line of sight will then be reflected back along the same path. As a result, the observer looking through the telescope will see the dash marks of the target image centered on the crosshairs. This is known as a *zero-zero* reading because there is no displacement of the target image and no tilt of the mirror in either direction.

In auto-reflection, the observer must always focus the telescope to twice the distance between the telescope target and the mirror. This is done because, in reflection from a flat mirror, the image of an object seen in a mirror appears to be at a distance behind the mirror that is equal to the distance of the object in front of the mirror. Any slight movement of the mirror from its perpendicular position will be shown by dash marks of the target image moving across the crosshairs.

Auto-Reflection Angle Mirror. All mirrors must be coated with reflective coatings. Mirrors coated on the back are not satisfactory for auto-reflection, because a certain amount of light is reflected from the front surface, which causes multiple images. Therefore, the mirrors used in auto-reflection, as illustrated in figure 6-24, are all front-surfaced mirrors. This means that

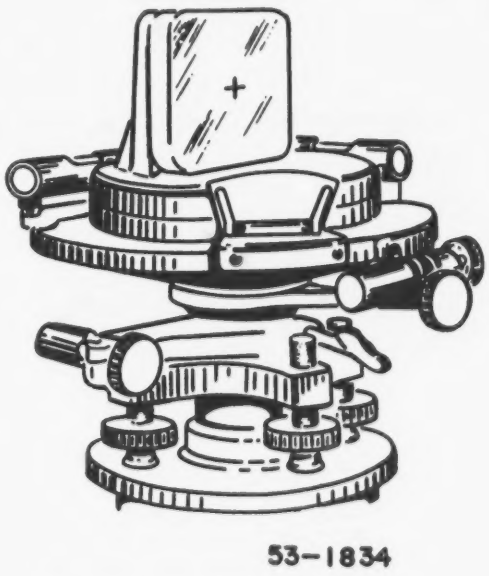

Figure 6-24. Auto reflection angle mirror.

the surface facing the telescope is the mirrored surface. The mirrors are coated with either aluminum or chromium.

The mirrors are checked by precision inspection for flatness so that regular reflection will occur when they are used. These mirrors are flat within 17/1,000,000-inch. Several sizes of mirrors are available. A suitable box is supplied for storage when the mirrors are not in use.

The base of the mirror is more or less the base of a transit. This permits the measuring of angles when the mirror is turned to the right or left of the vertical axis. When you clean these front-surfaced mirrors, be extra careful to avoid scratching; and investigate thoroughly the possible action of a solvent upon such a surface. It is safe to use a soap solution, but clean exclusively by flushing whenever possible. Never touch the mirrored surface with your fingers. Handle it from the base. Never wipe the mirrored surface. Cleaning fluid and optical cleaning paper should be kept available.

Exercises (899):

1. On what principle is auto-reflection equipment based?

2. How is a zero-zero reading obtained?

3. How can you tell if the auto-reflection mirror is exactly perpendicular to the line of sight?

4. How should you clean an auto-reflection mirror?

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Answers for Exercises

CHAPTER 1

Reference:

800 - 1. Cellulose.
800 - 2. Synthetic resin.
800 - 3. Cellulose.
800 - 4. Synthetic resin.
800 - 5. Thermosetting.
800 - 6. Thermoplastic.
800 - 7. Thermoplastic.
800 - 8. Thermosetting.

801 - 1. e
801 - 2. c
801 - 3. d
801 - 4. b
801 - 5. a
801 - 6. g
801 - 7. f
801 - 8. f
801 - 9. g
801 -10. g

802 - 1. Stack the sheets on top of each other, placing the smaller ones on top of the larger ones.
802 - 2. They should be stored at approximately a 10° angle from the vertical to prevent buckling. Place the sheets tightly together so they will give support to each other.
802 - 3. Store the canopy so that there is ample support, keep covered with cloth or soft paper to protect it from dust, and ensure the storage area temperature does not exceed 120° F.
802 - 4. Apply a protective coating to the surfaces.

803 - 1. a. False.
b. True.
c. False.
d. True.
e. True.
f. False.

803 - 2. a. Cleaning of transparent plastics should be done in the shape, if at all possible, to avoid causing water spots.
c. A damp chamois should be used, not cheesecloth.
f. A dry cloth should never be used because of the possibility of scratching the surface.

804 - 1. a. Mechanical.
b. Mechanical.
c. Material.
d. Material.
e. Mechanical.
f. Material.

804 - 2. a. Sand or buff out the scratch provided the panel thickness and optical qualities remain within technical order limits.
b. Same as above.
c. No corrective action is required if the bubbles are well scattered and do not impair vision, otherwise the panel is replaced.
d. If visibility or window heating is not impaired, no action is required. If visibility or window heating is impaired, replace the panel.
e. Replace the panel.
f. Replace the panel.

805 - 1. Caused by the action of solvents or solvent vapors.
805 - 2. Caused by a directional stress set up by cold forming excessive loading, improper installation, improper machinery, or a combination of these.
805 - 3. Caused by a deep scratch, chip, or pit, not being completely removed.
805 - 4. Caused by a surface defect or by not removing enough plastic to blend a damaged area during a restoration attempt.

806 - 1. Replace the masking tape to within 1/4 inch of the scribe lines.
806 - 2. Adjust the blade guides as close as possible to the work surface.
806 - 3. A blade that is fine enough to have at least two teeth cutting at all times should be selected.
806 - 4. Reduce the rate of feed and amount of cutting pressure.
806 - 5. Use a slower drill speed and feed, and less pressure.
806 - 6. You should use a drill lubricant (mild soap solution) and lift the drill from the work frequently to let it air-cool.

807 - 1. The radius used should be equal 180 times the thickness of the plastic sheet being cold formed.
807 - 2. Circulating air oven.
807 - 3. Heat lamp should be placed 18 inches from the plastic and arranged on 7- to 8-inch centers in a bank sufficiently large enough to cover the maximum size sheet involved.
807 - 4. Excessive material should be allowed for on the plastic sheet for handling purposes.

808 - 1. (1)
808 - 2. (6)
808 - 3. (2)
808 - 4. (2)
808 - 5. (1)
808 - 6. (3) and (4)
808 - 7. (3) and (4)
808 - 8. (5)

809 - 1. This permits the intermingling of the two surfaces to be cemented.
809 - 2. It is always preferable to cement flat surfaces rather than curved.
809 - 3. Visually inspect for at least 90 percent firmly bonded area in the joint. The remaining 10 percent may have bubbles and/or dry spots, unless otherwise noted in applicable drawings.
809 - 4. Mask the surrounding area, using a pressure-sensitive tape, impervious to the action of the adhesive.
809 - 5. It remains in the jig for 4 hours; and an additional 4 hours (25 hours or 4 hours at 150° F. for craze resistant acrylic plastic) should elapse before the assembly is subjected to handling or heat treatment.
809 - 6. To avoid stress concentrations.

810 - 1. Do not approach the softening point of the plastic when heat treating.
810 - 2. 48 hours at 122° F. (50° C.).
810 - 3. Reduce the heat-treating temperature and extend the heat-treating time period.
810 - 4. 24 hours.
810 - 5. Plastic parts that have been annealed may be cooled by turning off the oven, leaving it inside; removing it from the oven — aircooled; and controlled lowering of the temperature in the oven (elevated temperature annealing).

811 - 1. Inner layer.
811 - 2. Between 0.015 to 0.200 of an inch thick.
811 - 3. When the outer layers are of unequal thickness.
811 - 4. 165° F.
811 - 5. The same mounting method used by the aircraft's manufacturer should be employed.

812 - 1. The material should be conditioned for a period of about 24 hours at a temperature ranging from 80° F. to 90° F.
812 - 2. The temperature should be at least 80° F.
812 - 3. Apply clear varnish.
812 - 4. Dope-type cement should be used.

813 - 1. Compare the number, length, size and depth of the scratches with the specifications of the applicable -3 TO.
813 - 2. Use an optical micrometer to determine how thick the panel will be after the scratch is polished out and compare the remaining thickness to the -3 TO specifications.
813 - 3. No 320A.
813 - 4. Light pressure and 1400 RPM.
813 - 5. Three rectangles or squares are marked on the undamaged surface around the area to be repaired. The smallest rectangles is the polish limit for the first abrasive used. The second smallest rectangle is the polish limit for the second abrasive used. The largest rectangle is the polish limit for the third and subsequent abrasives used.

814 - 1. Excessive stresses are apt to cause the plastics to craze.
814 - 2. Because different size and material composition of screws are usually used in plastic assemblies. The cardboard diagram will enable you to return the correct screw to the hole.
814 - 3. To check and see if the frame assembly shifted during the removal and installation of the canopy.
814 - 4. If sealants are difficult to remove with the phenolic or hardwood scraping tool.
814 - 5. Because acrylic plastics expand and contract approximately three times as much as the metal channel in which they are mounted.
814 - 6. The possibility of inducing unnatural stresses and hole misalignment are reduced.

CHAPTER 2

815 - 1. Mat-molded fiberglass.
815 - 2. Honeycomb fiberglass.
815 - 3. Laminated fiberglass.
815 - 4. Honeycomb fiberglass.
815 - 5. Mat-molded fiberglass.

816 - 1. (1)
816 - 2. (2)
816 - 3. (1)
816 - 4. (3)
816 - 5. (1)
816 - 6. (2)
816 - 7. (3)
816 - 8. (3)
816 - 9. (2)
816 -10. (1)

817 - 1. Class III.
817 - 2. Major.
817 - 3. Minor.
817 - 4. Class I.
817 - 5. Class II.
817 - 6. Class II.
817 - 7. Minor.

818 - 1. a. False.
b. True.
c. False.
d. True.
e. True.
f. True.
g. False.
h. True.
i. True.
j. False.

818 - 2. a. PVA is used as a parting agent, not a binder.
c. A catalyst is needed for changing the resin from a liquid to a solid. A promoter is a drying agent.
g. Never mix cobolt and DDM directly together. Always add the DDM last, after the resin and cobolt have been mixed together.
j. The air circulating furnace should be capable of maintaining a temperature of 220° F. to 25° F. not 120° F. to 150° F.

819 - 1. The area should be beveled 150° to 45° on both sides, leaving one-third thickness of the panel remaining.
819 - 2. Whether the repaired area is going to air or heat cured.
819 - 3. Leave resin in closed container and wait until resin reaches room temperature.
819 - 4. Wash with soap and water at frequent intervals.
819 - 5. Aluminum plates, backed with PVA film, are clamped to the part over the repair by using C-clamps.
819 - 6. By applying heat.
819 - 7. Heat lamps should be placed directly over the repair area at a distance of about 30 inches. Warmer or colder surrounding areas will require adjustment of the heat lamps.
819 - 8. Additional heat and curing time is required.

820 - 1. The phenalic squeeze is used to smooth out the repair and to remove air bubbles and excessive resin in the impregnated cloth layer before curing the repair.
820 - 2. To provide materials for repairing parts manufactured from different types of resins and to provide a choice of curing methods.
820 - 3. The reason for using a vacuum pump is to apply uniform pressure to the fiberglass surface.
820 - 4. A pyrometer, when hooked to a thermocouple wire, is used to indicate the surface temperature of the repair area when heat is being used to cure the repair.

821 - 1. For the step-joint cutout a sharp knife or specially prepared cutter is used. For the scarf method, sanding tools are used.
821 - 2. The scarf method is used for small repairs up to three or four inches, especially when the facings are constructed of a thin weave of glass cloth which would make it difficult to peel.
821 - 3. For the step-joint method, the number of damaged plies determine the overall size of the cutout. For the scarf method, the cutout area is scarfed back to a distance of at least 50 times the total face ply thickness.

822 - 1. The direction of the weave determines the different strength properties of fiberglass cloth.
822 - 2. Finishes are needed on fiberglass cloth to prevent abrasion between the glass filaments, and to provide a coupling agent for the resin.
822 - 3. The strength requirement and type of resin to be used.
822 - 4. This finish is used with polyester, epoxy, and phenolic laminates, which require wet and dry strength properties.

823 - 1. (1)
823 - 2. (1) and (2)
823 - 3. (3)
823 - 4. (1)
823 - 5. (1) and (2)
823 - 6. (2)
823 - 7. (2)
823 - 8. (1)
823 - 9. (1) and (2)
823 -10. (2)

824 - 1. Duxseal putty should be about the size of your thumb and be placed at least 3 inches from the outer ply of the repair area.
824 - 2. The breather strip should be 1/4 inch think and 1 inch wide and placed approximately 1 inch from the wet laminate.
824 - 3. At least 1 inch beyond the strip of Duxseal putty.
824 - 4. Approximately 1/2 inch from the wet laminate.
824 - 5. Using the radius end of the squeegee, start approximately at the center and sweep toward the edge of the repair. Use a slow motion to sweep out the bubbles along with the resin.
824 - 6. When using rubber-type squeegees, the oil reduces the frictional drag.
824 - 7. Insufficient vacuum pressure.
824 - 8. When the curing temperature is above 250° F.

825 - 1. c, f, e, b, h, d, a, g
825 - 2. c, b, e, d, a

826 - 1. False.
826 - 2. True.
826 - 3. True.
826 - 4. False.
826 - 5. True.
826 - 6. True.
826 - 7. True.
826 - 8. False.
826 - 9. False.
826 -10. True.

827 - 1. Padded dollies or padded racks.
827 - 2. Solid laminated edgeband area.
827 - 3. a. Stored in dry area.
b. Suitable crates or padded racks.
c. Out of the weather.
d. Use only paper or similar material to protect the surface during storage.

828 - 1. Relatively high strength and versatility.
828 - 2. a. Glass cloth impregnated with polyester resin.
b. Glass cloth impregnated with nylon and phenalic resins.
828 - 3. Polyester resins.
828 - 4. Epoxy resins.
828 - 5. Blocks of various thicknesses and cell size or precut to proper thickness.

829 - 1. Yes.
829 - 2. No. Change rectangular to read "round or oval;" add the letter "d" to the word shape.
829 - 3. Yes.
829 - 4. No. Insert "except Class I repairs" after the phrase "For all repairs."
829 - 5. No. Change "facing" to read "core."
829 - 6. No. Delete the word "all' and add on the sentence "on which they have received training."

830 - 1. Direction of the threads in the original facings.
830 - 2. Flush Fit Method.
830 - 3. Position core material on a contour mold, similar to repair area, and then place the core material under 20 inches minimum vacuum pressure; heat to 300° F.-320° F. for 30–40 minutes and cool to 120° F. or less before removing vacuum.
830 - 4. Interlocking method, with a normal overlap of 1/2 to 1½ core cells.

831 - 1. True.
831 - 2. False.
831 - 3. False.
831 - 4. False.
831 - 5. True.
831 - 6. True.
831 - 7. True.

832 - 1. Use a room temperature curing resin.
832 - 2. When preparing a pressure blanket, it should be made from 0.020 inch thick PVA, cut so that it will conform to the area to be covered and can be clamped to a suitable stretching bar.
832 - 3. The stretching bar should be constructed so they can be clamped evenly to two sides of the blankets and provide a means of attaching to a rigid source to maintain the stretched conditions.
832 - 4. Pre-heat the blanket for 10 minutes at 260° F.
832 - 5. The mold surface is treated with a parting agent such as cellulose acetate, lacquer, silicone grease, PVA, vinylite or cellephane.
832 - 6. Apply several coatings of parting agents.

833 - 1. Mild detergent with water added.
833 - 2. MEK.
833 - 3. Approximately 4 inches adjacent to the damaged area.
833 - 4. Outline the area with a grease pencil.
833 - 5. Sanding and light seed blasting.

834 - 1. d, b, c, a, h, g, f, e
834 - 2. f, c, a, e, h, d, b, g, i

835 - 1. By using a temporary mold or block during the first face ply buildup.
835 - 2. The replacement core is coated with catalyzed resin on all sides (edges), leaving the bottom surface uncoated.
835 - 3. Make the cutout ply area approximately 2 inches larger than the first ply cutout area on the opposite face repair.
836 - 1. Hold the electrode gun at least six inches away from any object and press the switch button. The indicator pointer should swing to the right and stop at zero. Make necessary alignment corrections by turning the zero adjustment knob as required to zero the pointer.
836 - 2. Fine abrasive paper or an alcohol type solvent.
836 - 3. At least once or twice a week or prior to use if used less frequently and at any time erroneous readings are suspected.
836 - 4. Readings will be taken over the entire radome surface at 6 inch intervals. Reading should not be attempted within 3 inches of metal edges or microwave absorbing material.
836 - 5. Radome can be placed in an air circulating oven at a temperature between 150° F. and 170° F.
836 - 6. A reading of five or less.

837 - 1. Yes.
837 - 2. No. Change Class II to read Class I.
837 - 3. No. Change TO 1-1A-12 to read TO 1-1-24.
837 - 4. Yes.
837 - 5. Yes.

CHAPTER 3

838 - 1. Aluminum foil.
838 - 2. The facings (skin).

838 - 3. Flat, tapered, combination flat and tapered.
838 - 4. The bay area is the flat section of a honeycomb panel.
838 - 5. The area between the flat area and the flanged area is known as the transition area.

839 - 1. Class I.
839 - 2. Class I.
839 - 3. Class II.
839 - 4. Class III.
839 - 5. Class III.
839 - 6. Class IV.

840 - 1. The tapping method produces good results where the facings are not firmly attached to the core material.
840 - 2. Either a low tone or dull thud is produced.
840 - 3. This assures *complete* coverage of the panel being inspected.
840 - 4. The spur wheel, when run across a honeycomb panel at a constant speed, produces a different tone over defective areas.
840 - 5. Skin delaminations.
840 - 6. Whether a deep scratch has penetrated the clad surface.

841 - 1. a. No.
b. Yes.
c. No.
d. No.
e. Yes.
f. No.
g. Yes.
h. Yes.
841 - 2. a. Delete "checked for broken seals" and add "turn on and purged (cleaned out)" after the word "must."
c. Double-backed tape should be added to the list of items.
d. Change "90°" to read "45°."
f. Delete the last portion of the statement starting with the "keeping," and add "obtaining a good vacuum" after the word "in."

842 - 1. When additional space is needed for slicing thick core material.
842 - 2. The cutter should be adjusted to cut no more than 1/4 of an inch material at any setting.
842 - 3. Double-backed tape is applied to the upper surface of the fixure assembly for holding the core material in place when angular cuts are being made.
842 - 4. By holding the cylindrical core cutter perpendicular to the core material being cut.
842 - 5. A knockout hole is provided in the upper face of each cutter.

843 - 1. Heat lamps.
843 - 2. Heat gun.
843 - 3. Heat blanket.
843 - 4. Heat blanket.
843 - 5. Heat gun.
843 - 6. Heat blanket.
843 - 7. Heat lamp.
843 - 8. Heat gun.
843 - 9. Heat blanket.
843 - 10. Heat blanket.

844 - 1. 240° F.
844 - 2. 350° F.
844 - 3. Maximum strength is obtained.
844 - 4. 12° F. per minute.
844 - 5. Evenly distribute the pressure throughout the repair during the curing cycle.
844 - 6. 10 psi.
844 - 7. 240° (±10°) F.

845 - 1. Paste adhesives have a short work life.
845 - 2. The adhesives have a tendency to thicken.
845 - 3. 0.020 to 0.025 thick.
845 - 4. When the mixture is an even blue color.
845 - 5. 80° F.
845 - 6. 30 to 40 minutes.

846 - 1. False.
846 - 2. True.
846 - 3. False.
846 - 4. True.
846 - 5. True.
846 - 6. False.
846 - 7. False.
846 - 8. True.
846 - 9. True.
846 - 10. False.

847 - 1. b and c
847 - 2. a
847 - 3. e
847 - 4. d
847 - 5. a
847 - 6. a
847 - 7. c
847 - 8. d
847 - 9. e
847 - 10. d

848 - 1. Epon 815/curing agent "T"/microballoons.
848 - 2. Corfil.
848 - 3. Corfil.
848 - 4. Foam adhesive.
848 - 5. Foam adhesive.
848 - 6. Epons/Versameds/microballoons.
848 - 7. Corfil.
848 - 8. Epon 815/curing agent "T"/microballoons.
848 - 9. Foam adhesive.
848 - 10. Corfil.

849 - 1. When tools and equipment for cutting the aluminum material is available.
849 - 2. An increase bond area is created.
849 - 3. Because glass cloth with these finishes has good wet and dry strength properties.
849 - 4. Glass cloth No. 128 is thinner.

850 - 1. True.
850 - 2. True.
850 - 3. False.
850 - 4. True.
850 - 5. False.

851 - 1. Trichlorethylene.
851 - 2. The surface should be scrubbed with the cleaner and not allowed to dry by evaporation.
851 - 3. The aluminum wool is used to abrade the faying surfaces of the repair skin area.
851 - 4. Aladized.
851 - 5. The area should be cleaned further. A break indicates that the surface is still contaminated.

852 - 1. Chemical cleaning of the surface is required.
852 - 2. MEK and lacquer thinner are mixed on a one-to-one ratio.
852 - 3. Sanding of the plastic surface with 320 grit or finer abrasive sheet.
852 - 4. They should, at room temperature.
852 - 5. By mixing the mixture on a hard clean surface using a knife or spatula.
852 - 6. First sand with 280 to 320 grit abrasive sheets to remove ridges, then use a finer abrasive sheet, such as 400 grit, to meet smoothness requirements.
852 - 7. Use a knife or spatula wet with MEK or lacquer thinner.

853 - 1. The size of the dent.
853 - 2. The hooked end acts as a pulling force to straighten the dent skin from inside the panel.
853 - 3. Only through the skin area.
853 - 4. Placement of the clear plastic base over the mandrel.
853 - 5. The mandrel is pulled upward.
853 - 6. Usually a potting compound is injected into the drilled holes, filling the void created in the core. Then either a metal or glass cloth overlay is added.

854 - 1. To aid in the adhesive flow between the skin and core.
854 - 2. To keep from drilling into the core materials.
854 - 3. To allow the adhesive to form a maximum bond line.
854 - 4. To avail trapping air between the skin and core.
854 - 5. To permit angle delivery if more convenient.
854 - 6. To eliminate stress concentrations at the ends of the crack.
854 - 7. To provide at least 1½ inch overlap on both sides of the cutout.
854 - 8. To speed up the drying.

855 - 1. Drill a small hole at a low point and check for water seepage.
855 - 2. It should be conducted for eight hours, at temperatures between 150° F. to 180° F.
855 - 3. A router should be used.
855 - 4. The hole should be drilled or cut at least one inch from the assembly end and two inches from the extremely trailing edge.
855 - 5. The vacuum pressure should be no more than 20 inches Hg; the temperature should be maintained at 180° for a period of one hour.
855 - 6. When 90 percent of the water has been removed and no dense pockets are present.

856 - 1. b. Lightly sand surface of the aluminum skin with 400 grit abrasive.
e. Prepare plastic sheets.
f. Position the thinner plastic sheet on bottom side.
j. Prepare potting compound.
l. Remove air bubbles.
n. Remove plastic sheets.
856 - 2. b. Position overlap in place.
d. Test for proper bond.

857 - 1. a. False.
b. True.
c. True.
d. False.
e. True.
f. True.
g. False.
h. False.
i. True.
j. False.

857 - 2. a. All core replacement repairs require overlays.
d. Glass cloth replacement core plugs are cleaned with MEK.
g. Aluminum replacement core plugs are cut 0.0156 larger than the cavity.
h. The cavity cells are also "buttered" with potting compound.
j. Foam tape adhesive is also applied to the cells of the cavity.

858 - 1. a. No.
b. No.
c. No.
d. No.
f. No.
858 - 2. a. Reverse the words "length" and "width."
b. Delete the remaining portion of the statement starting with "cell etc." Insert the following "thickness and material of the honeycomb panel skin."
c. Delete the words "equal to" and insert "0.004 to 0.006 of an inch thicker than" after the word "be."
d. Change "120" to "180."
e. Insert the word "not" between the words "is removed."

859 - 1. Flush repair.
859 - 2. Combination repair.
859 - 3. Nonflush repair.
859 - 4. Combination repair.
859 - 5. Combination repair.

860 - 1. a. Original size - 4½" by 5¼", New size - 5½" by 5¾".
b. Original size - 5½" by 5¾", New size - 6½" by 6¼".
860 - 2. Maximum size - 8 inches wide, 9½ inches deep.

861 - 1. The aircraft must be jacked to a jig position.
861 - 2. The work area should be cleared of all objects that could cause additional damage. Rivit shavings and bits and pieces of rivits should be thoroughly removed from padded surfaces where honeycomb panels will be placed.
861 - 3. Be careful not to damage or elongate mounting holes on the aircraft structure.
861 - 4. Inspect the panel for signs of damages received during shipment.
861 - 5. They should be drilled at the aircraft after the panel has been fitted to the aircraft opening.

CHAPTER 4

862 - 1. (1) They seldom break or sever even under strains.
(2) They are stronger than steel rods or tubing of the same size.
(3) Their failure is never abrupt but is progressive over periods of extended use.
(4) They flex without setting and can easily be routed around obstacles.
(5) They can be installed without a great degree of sagging.
(6) They will not work—harden as a result of vibration.

863 - 1. True.
863 - 2. False.
863 - 3. False.
863 - 4. True.
863 - 5. False.
863 - 6. True.
863 - 7. True.
863 - 8. False.

864 - 1. Nonflexible carbon steel cable.
864 - 2. Nylon coated cables.
864 - 3. Flexible carbon steel cables.
864 - 4. Nonflexible corrosion resistant steel cable.
864 - 5. Nylon coated cables.
864 - 6. Carbon steel cable.

865 - 1. Repair.
865 - 2. Replace.
865 - 3. Okay.
865 - 4. Replace.
865 - 5. Replace.
865 - 6. Okay.
865 - 7. Repair or replace.
865 - 8. Replace.

866 - 1. d
866 - 2. g
866 - 3. c
866 - 4. a
866 - 5. b
866 - 6. j
866 - 7. i
866 - 8. e
866 - 9. f
866 -10. h

867 - 1. Use diagonal or side cutters.
867 - 2. 7/32 of an inch in diameter.
867 - 3. Insert cable end approximately one-half the distance into a terminal, then bend the cable to a 45° angle, and straighten the cable back to normal and push it the remaining distance into the terminal.
867 - 4. Place terminal securely in a vise and straighten it with a mallet or with a moderate pressure from the jaws of the vise.
867 - 5. Elongation of the terminals during swaging.
867 - 6. Wrap cable with masking or friction tape and cut in the middle of the tape, so that a section of tape will remain on each end of the cut cable.

868 - 1. Install the feed guide on the swager.
868 - 2. Rotate terminal 90° before starting the second pass to remove the flash developed by the first pass.
868 - 3. Rotate rolls to the No. 1 starting position.
868 - 4. Rotate the cable and terminal 45° before making the third pass.
868 - 5. Check the equipment for:
  a. Use of improper size rolls.
  b. Damaged front plate.
  c. Damaged bearings in the swaging machine, allowing rolls to separate.
  d. Recheck operation steps for possible source of trouble.

869 - 1. Seated against the terminal and front die.
869 - 2. Light pressure is maintained on the cable toward the front of the swager.
869 - 3. They should be lightly oiled.
869 - 4. It should be placed in the bench cradle.
869 - 5. Using both hands, hold the terminal-cable assembly about 1 inch from either side of the ball-end-inserted into the cavity of front (nose) die.
869 - 6. The air must be shut off.
869 - 7. Always use the safety guard.
869 - 8. 3/4 of an inch.
869 - 9. The terminal is inserted slowly through the dies.
869 -10. Cut cable.

870 - 1. 60 percent of the minimum allowable break strength is applied for 3 minutes.
870 - 2. Hydraulic work cylinder within the swage pull tester.
870 - 3. Overloading smaller diameter cables.
870 - 4. Two soft copper blocks.
870 - 5. When the slipping occurs when testing larger diameter size cables.

CHAPTER 5

871 - 1. 1100 (½ hard) or 3003 (½ hard).
871 - 2. 2024-T or 5052-0.
871 - 3. Corrosion-resistant steel.
871 - 4. 6061-T.
871 - 5. 1100 (½ hard) or 3003 (½ hard).
871 - 6. 2024-T or 5052-0.
871 - 7. Corrosion-resistant steel.

872 - 1. c.
872 - 2. d
872 - 3. f
872 - 4. a
872 - 5. b

873 - 1. True.
873 - 2. False. Change "AN819 sleeve nut" to read AN817 sleeve nut."
873 - 3. True.
873 - 4. False. Change "block" to "natural."
873 - 5. False. Delete "natural aluminum" and insert "blue."
873 - 6. True.

874 - 1. Replace.
874 - 2. Repair.
874 - 3. Replace.
874 - 4. Replace.
874 - 5. Repair.

875 - 1. Use the damaged tubing as a template.
875 - 2. Make a template of wire at the aircraft between the connecting points.
875 - 3. Install bends in the tubing.
875 - 4. The saw blade should have at least 32 teeth per inch.
875 - 5. Apply only light pressure to the cutting wheel by intermittently twisting the thumbscrew.
875 - 6. Place the tubing in a flaring block (dies) and clamp the block in a vise.

876 - 1. By estimating the amount of metal needed to make the bend plus additional material for the flare.
876 - 2. By placing the original and replacement tubing side by side, aligning the starting points of the bends. Mark the required amount for both ends on the replacement tubing using the original tubing as a template.
876 - 3. By positioning the original tubing in the tube bender as if you were going to bend the tubing. Use the 0° mark on the radius block as a guide in marking the starting point. Each bend is marked in this way.
876 - 4. By placing both side by side, as close as possible, and marking the starting point, located earlier on the original tubing, on the replacement tubing.
876 - 5. After inserting the replacement in the tube bender, hold the original tubing close to the replacement piece, and rotate the replacement tube to match the angles on the original tubing.

877 - 1. ¾ inch in diameter.
877 - 2. By turning a handcrank that is geared to the forming die.
877 - 3. When bending thin wall tubing.
877 - 4. Move the mandrel slightly forward of the required alignment point.
877 - 5. The slide bar should be adjusted firmly against the tubing, but not with sufficient pressure to prevent the slide bar from sliding through the slide block vise jaw.
877 - 6. The clamp block should tighten firmly against the tube to prevent the tube from slipping during the bending process.
877 - 7. a. Move mandrel forward.
  b. Tighten clamp block more firmly.
  c. Use a mandrel inside the wall tubing.
  d. Move mandrel backward.

878 - 1. Both the tubing and the ladle must be kept beneath the surface of the hot water.
878 - 2. You should wait until the fusible delay has solidified.
878 - 3. Place both the tubing and ladle in the tank of hot water and pour the fusible alloy back into the ladle.
878 - 4. The ends may be flattened or metal discs soldered in the ends.

879 - 1. True.
879 - 2. False. The flare should extend above the sleeve approximately 1/16 of an inch and be no larger than the largest outside diameter of sleeve.
879 - 3. False. A flare that is too short, should be reflared.
879 - 4. False. A flare that is too long, should be cut off and reflared.
879 - 5. True.

880 - 1. i, c, d, f, a, g, b, j, k, f, e, k, n, h, o.

881 - 1. The cone adjustment is made by matching the tubing outside diameter marks on the flaring center with the scribed index line on the spindle lead.
881 - 2. Flaring dies are slid into the channels on the vise jaws and are locked in place by turning knarled circular key into the arc slot in the flaring dies.

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881 - 3. The rate of speed is adjusted by turning the crank on the side of machine while the motor is running. For thin wall annealed aluminum alloy tubing, set the speed to a full rotation setting.

881 - 4. The travel of the spindle should be adjusted by moving the screw dial nut inward or outward with the level in the full forward location. Proper adjustment is obtained when the cone will flare the tubing without thinning out the flare. After the adjustment is made, secure the companion lock nut in place.

881 - 5. a. Adjust the spindle travel.
b. Reduce rotation speed.
c. Adjust stop finder.
d. Reduce rotation speed.

882 - 1. They are positioned in three milled slots on the face of head assembly, each separately held in place by a set screw. The squaring bit is located in the center slot.

882 - 2. By the overhang on the outer edge of the head assembly.

882 - 3. The same dies used to flare the tubing are used.

882 - 4. It should be adjusted sufficiently beyond the flaring dies to avoid the danger of the blades coming in contact with flaring dies.

883 - 1. c, b, a, d, f, e.

883 - 2. d, f, a, b, e, c, g, h.

884 - 1. False.

884 - 2. False.

884 - 3. False.

884 - 4. True.

884 - 5. False.

884 - 6. True.

885 - 1. It should be 0.002 to 0.005 of an inch less than the inside diameter of the tubing.

885 - 2. Tubing connectors.

885 - 3. After the nut has been finger tightened.

885 - 4. Normally one full complete turn plus an additional 1/6 of a turn.

885 - 5. The sleeve.

885 - 6. 0.003 to 0.008 of an inch.

885 - 7. The sleeve may rotate around the tubing, but only a 1/64 of an inch longitudinal movement is allowed.

885 - 8. If the tubing should be tested to twice the intended working pressure.

886 - 1. True.

886 - 2. False. Permaswage repairs can be accomplished on tubing materials specified in TO guidelines.

886 - 3. False. The ratchet aids in cutting tubing in limited access area.

886 - 4. False. Only three different sizes of tube cutters are available because each can be adjusted to various diameters and wall thicknesses.

886 - 5. True.

886 - 6. True.

886 - 7. False. Swage pressure should be 5500 psi.

CHAPTER 6

887 - 1. D

887 - 2. D

887 - 3. S

887 - 4. S

887 - 5. D

887 - 6. S

888 - 1. e

888 - 2. i

888 - 3. a

888 - 4. f

888 - 5. d

888 - 6. g

888 - 7. b

888 - 8. h

888 - 9. c

888 -10. j

889 - 1. 10 lbs.

889 - 2. 12.5 lbs.

890 - 1. Calculation method.

890 - 2. Component method.

890 - 3. Trial weight method.

890 - 4. Calculation method.

890 - 5. Component method.

891 - 1. c

891 - 2. f

891 - 3. b

891 - 4. g

891 - 5. e

891 - 6. a

891 - 7. d

892 - 1. It is reflected.

892 - 2. It changes direction.

892 - 3. Irregular reflection.

892 - 4. Regular reflection.

892 - 5. It is refracted away from the normal.

892 - 6. It is refracted.

893 - 1. False. Change "reflect" to "refract."

893 - 2. True.

893 - 3. False. Omit the "either" and "or," and insert the word "and" between "reflected" and "refracted."

893 - 4. True.

893 - 5. True.

893 - 6. False. Change the word "reflected" to "refracted."

893 - 7. True.

893 - 8. True.

894 - 1. g

894 - 2. h

894 - 3. b

894 - 4. a

894 - 5. a

894 - 6. c

894 - 7. d

894 - 8. e

894 - 9. b

894 - 10. f

895 - 1. Replace the word "parallel" with "magnification."

895 - 2. Statement is correct as it reads.

895 - 3. Statement is correct as it reads.

895 - 4. Statement is correct as it reads.

895 - 5. Replace the word "magnification" with "detail."

896 - 1. Yes.

896 - 2. No.

896 - 3. No.

896 - 4. Yes.

897 - 1. When a tilting level is not available.

897 - 2. Rotating the standards and telescope about its vertical axis.

897 - 3. By releasing the vertical clamping screws.

897 - 4. By adjusting the horizontal tangent screws on the transit.

897 - 5. By adjusting the vertical tangent screws.

898 - 1. Adjust leveling screws to plumb the vertical axis of the tilting dumpy level.

898 - 2. Attach an optical micrometer to the level.

898 - 3. Release the clamp screw.
898 - 4. Adjust tangent screw.
898 - 5. Raise or lower the eyepiece end of the tilting level.

899 - 1. Reflection of light from a flat mirror.
899 - 2. By adjusting the mirror so that it is exactly perpendicular to the line of sight.
899 - 3. The telescope crosshairs will be centered between the dash marks nearest the center of the target.
899 - 4. By flushing with a soap solution.

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SUPPLEMENTARY MATERIAL

CDC 53153

AIRFRAME REPAIR SPECIALIST

(AFSC 47255)

Volume 5

IMPORTANT: Make the corrections indicated in this supplement before beginning study of this volume. This supplement contains "pen-and-ink" changes, replacement pages, and also some additional material. It is perforated and three-hole-punched so that you can tear out the replacement pages and insert them in your volume.

NOTE: This supplement is valued at 3 hours (1 point).

Extension Course Institute
Air University

94- 946

CHANGES FOR THE TEXT:

Pen-and-Ink Changes:

Page-Col	*Subject*	*Line(s)*	*Correction*
Cover		1	Change "53153 05 7720" to "53153 05 7702," and "(AFSC 53153)" to "(AFSC 47255)."
iii	Preface	18,19	Delete "and alignment" from the sentence.
iv	Contents	Below Chap 3	Add "3A Advanced Composite Bonded Materials. . . . . 95a."
iv	Contents	Chap 6	Delete "and Alignment" from chapter title.
1R		last line	Add the following sentence: "Thermoplastics retain their shape until they become unless from deterioration, damage, etc."
6L		2	Change "reoval" to "removal."
9R		10	Change "hand" to "hang."
13L		9 fr bot	Change "or" to "of."
15L		9	Delete "like" and after the word "are" add the following: "also recommended for the laminated materials."
15L		10	Before "face sheets," add the following: "Since the exterior surfaces of transparent plastic vinyl laminates are like."
20R		28 fr bot	Change "surface" to "frame surfaces."
29R		26	Delete the word "Although," and capitalize the "t" in "they."
29R		27 fr bot	Replace the word "this" with "PVA film."
30L		11	After "DDM" insert "(trade-name for MEKP)."
30L		16	Change "returns" to "retains."
30L		12 fr bot	Change "cobolt" to "cobalt."
46R		22 fr bot	Change "call" to "cell."
47	Fig 2-15		Place an arrow (⟷) across the front of the honeycomb cores (above LH column).
48R		12	Change "for" to "or."
48R		26	Change "get" to "set."
49L		last	Delete the quotation marks.
49R		1, 2	Delete "and dry enough to allow liquid to be squeezed out."
50L		17 fr bot	Delete "one or more cores" and insert "the core."
50L		16 fr bot	Delete the "s" from "cores."
53R		10	Insert the word "depot" after the word "during."
56	Fig 3-2 (left-hand side)		Delete the words "Fig. 2" and "Fig. 3."
67R		13	Change "bind" to "bond."
68L		5	Change "laps" to "lays."

2

Page-Col	Subject	Line(s)	Correction
69L		1	Change "DRA" to "DTA."
71L		last	Change "Garam" to "Garan."
82R		5 fr bot	Change "or" to "and."
72R		1-4 fr bot	Delete the entire second sentence.
73L		9	Change the equal signs in "MIL =T = 7003" to dashes "(MIL-T-7003)."
73R		21 fr bot	Change "channel" to "chemical."
79R		9 fr bot	Change "celles" to "cells."
82R		18 fr bot	Change "potter" to "potted."
85R	857-1,d		Change "EC-77CR" to "EC-776R."
85R	857-1,f		Change "0.006" to "0.004."
94R		4 fr bot	After "on" insert "doubler A of."
94R		3 fr bot	Change both "sizes" to "size."
94R		1,2 fr bot	Delete both lines a. and b.
99R		8 fr bot	Change "care" to "bare."
102L		21	Add the word "cable" after "MIL-C-5425."
106R		14	Insert the word "are" after the word "sizes."
120	Fig 5-7, Step 5.	line 1	Change "continued" to "continue."
		line 2	Change "band" to "bend."
122R		11	Add the following at the end of the line: "the upper left-hand illustration of figure 5-10."
122R		12	Add the following at the beginning of the line: "If the bend is flattened, as shown in."
136L		18 fr bot	Delete "usage with large diameter" and change "over" to "up to."
137L		4, 5	Between lines 4 and 5 insert the following new paragraph: "The use of 5052-0 aluminum alloy tubing with MS (flareless) fittings is not recommended. The 6061-T6 aluminum alloy tubing should be used or a replacement for 5052-0 tubing when it is necessary to install MS fittings."
137R		8	Change "1/16th" to "1/6th."
137R		8	After "required" add the following: ". . . when a mandrel is not used. When a mandrel is used, the number of turns required is determined by the diameter of the tubing."
141	Chapter title		Delete "and Alignment" from the title.
141 L		11-19	Delete this paragraph.
141L		21	Delete "and align."

Page-Col	*Subject*	*Line(s)*	*Correction*
141L		23	Change "both" to "balancing."
143R	888-6	2,3	Delete "to center of the rebalterline."
147R-162	Section 6-2		Delete this entire section and figures 6-8 through 6-24.

CHANGES FOR ANSWERS FOR EXERCISES:

165L	803-2	2	Change "shape" to "shade."
166R	818-2,g		Change "cobolt" to "cobalt."
166R	820-1		Change "phenalic squeeze" to "phenolic squeegee."
167R	828-5	1	Insert "blocks" after "precut."
168R	848-6		Change "Versameds" to "Versamids."
168R	851-4		Change "Aladized" to "Alodized."
171R	884-6		Change "True" to "False."
171R/172	891 through 899		Delete all answers.

Page Changes: Remove old pages and insert new pages as indicated. If replacement pages number more than those they replace, those pages in excess of the pages being replaced will carry letter designations. For example 20, 20a, 20b, etc.

Remove Pages	*Insert Pages*
95-96	95-96
123-124	123-124
169-170	169-170

2. If you had only one piece of glass cloth 22 inches square, what would the maximum size repair you could perform using the specification shown in figure 3-24, for the center panel repair?

861. Cite preparations, precautions and procedures involved in removing and replacing metal bonded honeycomb panels.

Under certain conditions, you will have to remove and replace metal bonded honeycomb panels. Some of these conditions are:

a. Damage exceeds TO specifications.

b. Addition of another repair to the panel violates TO limitations.

c. The time to replace a panel is less than the time it would take to repair the panel. In cases like this, returning the aircraft to immediate service is an important factor. The original panel is then repaired using normal processing and scheduling procedures.

d. The damage is such that the panel cannot be repaired on the aircraft properly.

Regardless of which condition dictates the removal and replacement of a metal bonded honeycomb panel, certain important work procedures must be foremost in your mind. Work procedures such as, proper removal techniques, work precautions to use to prevent damage during shop working practices, and installation techniques are the main factors to consider.

Removal Techniques. Whenever a metal bonded honeycomb panel is going to be removed, always check to see if the aircraft needs to be jacked to a jig position prior to removing the panel. And usually, if this is the case, the aircraft should not be moved or taken off jacks until the panel is replaced. Honeycomb panels are usually stress fitted when the aircraft was manufactured, and in order to be replaced, the same position or aircraft configuration used by the manufacturer during installation must be duplicated.

When removing the panel, care should be taken not to damage or elongate mounting holes on the aircraft structure. In cases where a panel is bonded on, such as the panel over the wheelwalls on the wings of the F-4 aircraft, take care *not* to scratch or scar the bonding surfaces. This will cause additional surface preparation when you replace the panel. Also, if the panel can be used to locate mounting holes and required cutouts, the panel should be removed with as little as possible removal damage. After the panel is removed, clean the mounting surface of all traces of old bonding agents and sealants. Inspect the mounting structure and plate nuts (if used) for damage.

Handling Precautions. After the panel has been removed, it should be handled with care. Work areas should be cleared of all objects that could cause additional damages. Rivet shavings, bits and pieces of removed rivets, all should be thoroughly removed from padded surfaces where honeycomb panels are to be placed. When replacement panels are received from base supply, they should be inspected for any damage incurred during shipment. In addition, every effort must be taken during the drilling and trimming of the new panel to prevent damage.

Replacement Procedures. Replacement panels come with fastener holes undrilled and a 0.200-inch trim allowance on all edges. Use hole finding methods previously covered to locate the correct locations. In many cases, holes in the new panel must be located after the panel has been trimmed and fitted to the aircraft opening. Always check TO guidelines before drilling fastener holes in a new panel in the shop area. Trim edges to fit by using a high speed router or equivalent means that will not separate the edges of the bonded panel. Drill and countersink holes to match the holes on the aircraft. When honeycomb panels are bonded in place, proper cleaning of the surface on the aircraft and the panel [illegible] MUST to insure proper bonding.

Mounting fasteners should not be shaved after installation and head protrusion normally should not exceed 0.025 of an inch. When panels have inaccessible areas, use blind fasteners, such as Jo-Bolt or Bulbed Cherrylock rivets. The strength requirements of the panel will determine the specific type of fastener to use.

Exercises (861):

1. What preparation is indicated upon finding that a bonded honeycomb panel you must remove is stress-fitted to the aircraft?

2. Prior to bringing a honeycomb panel into the work area, what work area preparation should be made?

3. What precautions should be observed when removing a honeycomb panel from the aircraft?

4. What is the first thing you should do to a honeycomb panel just received from supply?

5. Normally, where and when should the fastener holes for a new metal bonded honeycomb panel be drilled?

CHAPTER 3A

Advanced Composite Bonded Materials

WITH INTRODUCTION OF the F-15 aircraft, the "door" to advanced aircraft composite structural materials has opened. Prior to this time aircraft composite materials such as fiberglass-polyester and fiberglass-epoxy were limited in use to only secondary structural components (radomes, laminated and mat molded panels, etc.). The reason for this limitation was the fact that these earlier composite materials were low in specific stiffness, resulting in reduced compression load-carrying capability and overall structural stiffness requirements.

The development of advanced composite bonded materials, such as boron and graphite-epoxy composites, which have both excellent specific stiffness and strength properties, now makes it possible to use these composite materials in primary aircraft structural components either in the form of laminated skin panels or as part of bonded honeycomb panel assemblies. The advanced aircraft composite structures are significantly more efficient than their metal counterparts. Structural weight savings of 25 percent are quite feasible, and this savings could increase to 40 percent as design techniques are improved and developed.

So what does all this mean to you, the airframe repairman? How do you fit into the picture? It means that you must become acquainted with these new materials as soon as possible. As more and more aircraft use these new materials, sooner or later you'll be faced with the problem of repairing them. It is therefore extremely important that you know the unique characteristics of these materials, technical terms related to these materials, and the "do's and don'ts" associated with repair procedures.

This chapter will give you a basic foundation from which you can expand your knowledge of these new composite materials. First, we will look at just what these materials are and why they are being used. Then we'll turn our attention to the materials and techniques employed to repair these composite bonded materials.

NOTE: Throughout this chapter, especially those objective segments dealing with repair procedures, the information given will be primarily taken from TO 1F-15A-3-5. Presently this TO is the main source of this technical information. The intent here is to give you a basic foundation which you can work from as more and more aircraft use these materials. Remember, the final source for repair information is the specific -3 technical order for the aircraft being repaired—not this CDC.

3A-1. General Information

As with any new item, whether it is a piece of equipment or a new structural material, its to your advantage to quickly understand how this new item is going to affect you in the performance of your work. In order for you to do this, in regard to these new advanced composite bonded materials, you need a basic knowledge as to why these materials are being used, just what some of their unique characteristic features are, and the properties of the materials used in repairing them.

861a (Objective 900—for computer answer key and feedback reference only). Point out significant factors, including unique construction features and give reasons for the use of advanced composite bonded structures in today's aircraft.

Advanced composite bonded materials, when compared to the earlier composite materials such as fiberglass-epoxy, are as different as "night and day" in many respects, although there are some similarities. It is important that you become familiar with the similarities and differences so that you know exactly what you can do and can't do in repairing such materials.

Selection Factors. Advanced composite bonded materials have taken on new significance because of today's rapidly diminishing natural and energy resources. No longer is it enough to extend the state-of-the-art without considering energy drain and economics. A recent study of energy requirements has shown that energy savings of advanced composite materials over metal can be as high as 33 percent. This includes the cost of mining the raw materials, manufacturing of the parts, and the assembling of the final products. There is an abundant supply of raw materials for advanced composites, and their conversion to final form costs less than with metal. Besides being cost effective, advance composite materials have excellent fatigue and corrosion resistant qualities. They are lighter in wight than metal components but possess a high-strength-to-weight ratio. Damages resulting from impact are far less than those experienced by earlier composite structures. They won't weather or deteriorate in the presence of fuel or oil. And they have a service temperature range from 350° to 400° F.

Even with all of these outstanding qualities, they still require special handling and care. Most of the damage recorded to date has resulted from improper ground handling procedures. Also, the same problem of moisture contamination which plagued the earlier composite structures is still present with these materials. It is extremely important that whenever you are working around or with these advanced composite materials, you follow "to the letter" the instructions given in the -3 technical order.

Characteristic Features. Before getting into the unique features of these advanced composite structural materials, let's first define what composite materials are. Composite materials consists of high-strength filaments encased in a resin matrix, normally epoxy. What gives these new composite materials their outstanding qualities of high-strength and torsional stiffness has been the development of continuous filaments such as boron and graphite, the development of improved resin matrix materials, and the concept of crossplied laminates. The number of plies and their layup angles (in relation to the first ply laid up) determine the strength and stiffness of a composite structure. This is what the crossplied concept is all about. If all the plies ran one way, then the structure would be extremely strong in that direction, but very weak if loaded transversely (against the direction of the plies). Laying up the plies at angles of 0°, 45°, 90°, and 135° produces strength and stiffness in all directions within a part.

By varying the number of layers in each of these four directions, the strength and stiffness of a part can be tailored for its particular structural requirements. For example, in building a large composite structure, such as the B-1 horizontal stabilizer, plies are provided in the span-wise (0°) direction to impart binding strength. The amount of these layers varies from 2 at the tip to as many as 48 at the root. Sixteen layers at 45° and an additional 16 layers at 135° provide torsional stiffness. A minimum of 2 layers at 90° provides chord-wise strength.

This crossplied concept plays an important part when it comes to making repairs to these advanced composite structures. Special charts and exact measurements are required, as you will see later in the repair section for advanced composite structures.

The filaments are the primary load-carrying elements and the source of exceptional stiffness; in fact, they are the principal justification for the existence of these composites in the first place. The matrix (resin) has its own essential functions, without which there would be no composites. The matrix stabilizes the slender filaments against compression instability, loads and unloads the filaments at their ends, carries transverse loads in the individual layers, provides the body to the composite in its cured state to enable it to form integral laminates, prevents the filaments from dropping, and protects the filaments from abrasion.

Exercises (861a):

1. List six reasons why advanced composite bonded materials are starting to replace conventional aircraft construction materials.

2. What gives these new advanced composite bonded materials their outstanding qualities of high strength?

3. What is meant by crossplied laminate construction?

4. What are the functions of the matrix in composite construction?

5. What element of these advanced composite bonded materials is the main load-carrying element?

861b. (Objective 901—for computer answer key and feedback reference only). Given a list of descriptive statements, indicate whether the statement refers to either boron or graphite composite materials.

Now that you know why these advanced composite materials are coming into use and some of their related features, let's zero in on the two types which you will be working with—boron-epoxy and graphite-epoxy composites.

Boron-Epoxy Composite Materials. Boron filaments are produced by vapor deposition of boron trichloride onto 0.0005-inch diameter tungsten fibers. Boron filaments have a remarkably high modulus (stiffness) and tensile strength (450,000 psi). A single four-thousandths of an inch diameter boron fiber can easily pass straight through your finger if not handled carefully. Still, if you try to tie the filament into a knot, its stiffness—twice that of steel but one-fourth its weight—will cause it to break before you can pull the knot taut. Boron is not only stiffer, stronger, and harder than conventional metal, it is also lighter. Its density is roughly 71 percent that of aluminum and 44 percent that of titanium. Boron ranks next to diamonds in hardness.

Boron-epoxy composite materials are manufactured into various widths of pre-preg tape. A 3-inch wide piece contains 208 to 210 boron filaments per inch. The filaments are held together by a "B" stage epoxy resin (matrix) supported by a 0.001-inch-thick fiberglass cloth carrier (sometime referred to as scrim). A "B" stage resin is an intermediate stage in the reactions of the resin to heat and certain solvents. The resin will soften and swell, but it will not entirely fuse or dissolve.

Resin are manufactured to this stage to permit easy handling and processing of the resin impregnated materials prior to curing (C-stage). Boron-epoxy composite structures are very costly because of the high cost of tungsten and the slow, hard layup process used in the manufacturing of the structures. Research and development of machines to do the layup work will greatly reduce the manufacturing cost in the future.

Boron-epoxy composite materials are used when high-strength requirements exist. The higher the strength requirement, the higher the number of plies. Presently, it is used only in flat panel construction because of its high stiffness quality. It is used in the form of laminated sheets bonded together. These are either placed together directly over substructural members or are used as outer skin surface areas for honeycomb panels.

Boron-epoxy composite materials are easily distinguished by their black color. Painted boron-epoxy composite materials are identified by the telltale signs of its unique fabric pattern when closely examined.

Graphite-Epoxy Composite Materials. Graphite-epoxy materials are lighter and much less expensive than boron-epoxy materials. Its identifying color is also black, but a much darker black than the boron materials. Graphite-epoxy materials are stronger in tension than boron but lacks boron's high stiffness quality. For this reason, it is used where the strength requirements are less critical. Its tensile strength ranges from 50,000 to 100,000 psi. In terms of weight, graphite-epoxy materials are lighter than aluminum and even fiberglass. Its impact-resistant quality is less than that of the boron-epoxy materials. Therefore, extra caution must be taken when working with graphite-epoxy structures.

A graphite fiber has a diameter of eight ten-thousandths of an inch, finer than a human hair. Being five times thinner than boron fiber, a high degree of formability is possible. It can be used for parts which have sharp corners, whereas boron-epoxy cannot. This quality of formability permits graphite-epoxy materials to be formed into various-shaped substructural members, whereas the boron-epoxy materials are limited to flat surfaces.

Graphite fibers are made by subjecting strands of rayon to intense heat and pressure, after which, either a single filament (similar to the boron-epoxy materials) or a yarn (cloth) type of material is manufactured in the "B" stage resin condition. The yarn (cloth) type is used as the reinforcement material when maximum composite strength is required. This yarn (cloth) type of graphite-epoxy materials has flexibility and handling characteristics similar to those of fiberglass cloth.

The type of weave used depends on the shape and strength requirements of the composite part. The same basic types of weave patterns used for fiberglass are also used for graphite-epoxy yarn (cloth) materials. The type of weave pattern being used can be determined by closely examining the part.

Exercises (861b):

In the space provided, indicate whether the statement refers to boron or graphite composite materials by placing the letter "B" or "G" or both letters if the statement applies to both materials.

_____ 1. Its tensile strength is four times greater than the other.
_____ 2. It is five times thinner than the other.
_____ 3. Has flexibility similar to that of fiberglass cloth.
_____ 4. Uses an epoxy resin in its matrix.
_____ 5. Used only on flat surfaces.
_____ 6. Used on both flat and curved surfaces.
_____ 7. Next to diamonds in hardness.
_____ 8. Strongest of the two materials in tension.
_____ 9. The most costly of the two materials.
_____ 10. Formed into laminated sheets.

861c (Objective 902—for computer answer key and feedback reference only). Identify accurate statements related to the materials used to repair boron or graphite structures and give the correct answer for inaccurate statements.

The materials used to repair boron or graphite composite bonded materials are in themselves unique in many ways. Let's take a close look at "whats and whys" associated with the two materials presently used as patch materials—titanium patch plates and graphite-epoxy pre-preg fabric materials. But before we do this, there is one thing you need to know. Flush patches are not normally accomplished because undamaged materials would have to be removed, thus reducing the structural capability of the material being repaired.

Titanium Patch Plates. Titanium patch plates are used both on boron or graphite composite materials. They are fabricated from 6AL-4V annealed titanium foil 0.008 of an inch thick. Titanium foil is used because its expansion characteristics are similar to those of composite materials, and it provides adequate strength and stiffness in all directions. Also, it only slightly increases the structural weight of the item being repaired.

Titanium foil patch plates are available in a single ply form or a multiple-bonded ply form having as many as 10 plies. The multiple-bonded ply form is designed so that the largest ply is placed next to the composite material, with each additional ply (upward) from 0.700 to 0.800 of an inch smaller. Patch plates are available in three basic shapes consisting of various numbers of plies and sizes – round, oval, and square. The location and size of the damaged area will determine which one you will select. Whenever possible, a round patch plate should be used. As for the size, a minimum overlay of 1 inch, in all directions, from the damaged area is required. Titanium foil patch plates are designed primarily for flat surface repairs. But they have enough "give" to them that they can be used in areas having a very slight contour.

Unless your shop has an autoclave unit (a unit that generates heat and pressure) you will have to order multiple-ply titanium foil patch plates. You have to order them and *only* as the need arises. Titanium foil patch plates are not stored at base level. The reason is the high cost of the composite assemblies field repair parts patch kit at this time. It is more cost-effective to order patches on a demand basis. In the future, it may be possible with the lowering of the cost, to have these patch plates on hand at base level.

Graphite-Epoxy Pre-Preg Fabric. This fabric consists of graphite woven cloth impregnated with epoxy resin in the "B" stage condition. It is used to patch graphite-epoxy composite materials when it is impossible to use titanium foil patch plates because of the contour of the damaged area. In other words, it is an alternate repair method and should be used only under the condition stated above.

Graphite-epoxy pre-preg fabric must be handled with special care to prevent improper bonding. Whenever handling, cutting, or whatever, you must wear white lint-free cotton gloves to prevent contamination. This material must be kept in cold storage in its original container (plastic bag). It must be brought to room temperature while still in the plastic bag, prior to using. The plastic bag is necessary to prevent moisture condensation from forming on the fabric during the temperature changes.

Graphite-epoxy pre-preg patches are either circular or oval. The number of plies required is determined by the size and location of the damaged area. A 1-inch overlay (damaged area) is the minimum required. The plies are laid up with the largest ply placed next to the composite material, with each additional ply (upwards) smaller then the preceding ply. Technical order specifications will state the required dimensions for each ply. Also, it must be remembered that the warp direction of the fabric is parallel to its length. This is an important factor that must be considered during the layup process when making repairs. In a later objective segment, you will see how this comes into play.

Exercise (861c):

1. In the space provided, indicate whether the statement is true or false by placing the letter "T" or "F," and correct the false statements.

___ a. Normally flush patch repairs will be accomplished on boron or graphite structures.

___ b. Titanium is used for patching boron or graphite composite structures, mainly because of its high resistance to corrosion.

___ c. Titanium foil patch plates are designed primarily for curved surfaces.

___ d. When a titanium patch plate is not available, a graphite-epoxy pre-preg fabric patch can be used, regardless of the contour of the repair area.

___ e. The minimum repair overlap of both the titanium foil patch plates and graphite-epoxy pre-preg fabric patches should be 1 inch.

___ f. In order to properly perform a graphite-epoxy pre-preg fabric repair, your shop must have an autoclave unit.

3A-2. Repair Information and Work Procedures

By now, the question that must be foremost in your mind is "How do you repair boron or graphite-bonded-composite materials?" But before we get into answering this question there is one thing you need to know. There are no "quick fix" repairs when it comes to boron or graphite components. Repair procedures given in specific -3 technical orders must be followed to the "letter" if the repair being accomplished is to return the damaged component to its original load-carrying requirements.

As in any repair situation, an orderly step-by-step building process must be followed. This insures that nothing is overlooked and that the completed repair meets all repair requirements. This building process for boron- or graphite composite materials starts with the initial inspection evaluation and classification of the damaged area. This is where we will start to answer that question. These two steps provide the foundation that you work from as the repair is being accomplished.

861d (Objective 903—for computer answer key and feedback reference only). Specify appropriate factors and procedures to follow when evaluating and classifying damages to boron or graphite composite structures.

The initial repair procedures of evaluation and classification are critical steps in the repair of boron or graphite composite materials. It is on information derived from these two procedures that later repair decisions will be based.

Evaluation Procedure. As in all repair situations, one of the first questions you need to answer is "Just how extensive is the damage?" In cases involving

primary load-carrying structures, accurate and precise information is a *must*. Any damage, no matter how slight, on boron or graphite composite structures, dictates that a thorough inspection of the damaged area be accomplished. Any, in many situations, this is going to call for close coordination between you and the NDI specialist.

Your primary method of inspection is the coin-tapping procedure outlined earier for the conventional (aluminum skin) honeycomb panels. Tapping lightly with a coin on suspected delaminations or unbonded areas of skin gives off a dull, lifeless note, whereas an undamaged area produces a clear, metallic sound. When using this method, you must remember two things. First, this method obtains best results on thin skin areas. Results obtained on thick skinned areas are questionable because of the thickness and surface hardness of these composite materials. Secondly, you must be familiar with the internal construction features of the assembly you are tapping. False indications can be obtained by the difference in the sounds received when a panel is tapped over an internal bracing member (splice, reinforcement plates, etc.) versus an "open" area. An "open" area is one without internal bracing members other than the honeycomb core materials.

Damaged areas which have been exposed to rain or are suspected to have moisture contamination, especially when damaged core materials are involved, must be inspected by NDI specialists. This requirment also holds true when unsatisfactory results are obtained using the coin-tapping method or when there is any doubt as to the extent of the damage.

While performing this evaluation inspection, also make special note of any previously accomplished repairs as to number, location, and distance from the damaged area. These are important factors, because certain components have weight limitations and specific restrictions on how close patches can be together in certain areas. These facts, plus the estimated amount of damage, play an important "role" during the damage classification procedure.

Classification Procedure. Armed with the facts obtained during your evaluation step, you are now ready to accurately determine the classification of damage. Your determination must be precise because different classifications call for different repair procedures and materials.

Damages to boron or graphite-epoxy bonded structures fall into two major categories—negligible or repairable. The dividing line between these two categories is whether or not broken filaments are part of the damage. Each of these categories, based on the type of material involved, has limitations as to what is allowable damage and what must be repaired. Also given are instructions to follow when repairable limitations are exceeded.

At this time, there are 10 or more classes of repairable damages listed for both boron and graphite. It would be time-consuming and beyond the scope of this text to list them all. It is therefore important that when you reach the classification decision step, you consult the -3 technical order for the specific classification. Usually listed along with the particular classification limitations are the pages or figures of the needed repair procedures.

Exercises (861d):

1. What is the primary method of inspection for the airframe specialist in checking damaged boron or graphite composite structures?

2. What is the limitation associated with the method called for in question 1?

3. What factor will quickly indicate the major category of damage?

4. How can you insure that the entire damaged area is evaluated?

5. What should you do if you suspect that moisture has entered the damage area?

861e (Objective 904—for computer key and feedback reference only). Given damage evaluation data, cite specific factors as to the type, size, and shape of patch material required for boron or graphite composite repairs.

Normally, after the damaged area has been evaluated and the classification of the damage determined, you would start removing the damaged materils. But, this is not the sequence when boron or graphite composite materials are being repaired. There is still one more preremoval step that must be accomplished before you finally reach the removal stage. This step involves determining the type, size, and shape of the external patch materials needed—titanium foil patch plate or graphite-epoxy pre-preg fabric.

Determination Factors. Unless the damaged area is on a curved portion of a graphite-epoxy composite component, the type of external patch material you will be using is titanium foil patch plates. But what about the size and shape, and above all, the number of plies required in the patch plate? The way you solve this problem is by first finding the exact location of the damage on the component and secondly, by calculating the "effective" diameter of the damaged area before any damaged materials are removed.

Location factor. The exact location of the damage is necessary because of the crossplied concept of built-in strength requirements and variations in the number of plies throughout boron or graphite composite materials. You will find the exact location through the use of reference lines such as the chord line, fiber 0° line, water and buttlock station numbers, and zone areas. By using a combination of these different reference lines, you will be able to quickly pinpoint a given area on a component. Examples of how these line locations are used are shown in figures 3-25 and 3-26. Figure 3-25 is for a vertical stabilizer and figure 3-26 is for a stabilator. Figure 3-27 shows how zone locations, along with station numbers, are used.

Damaged diameter factor. Once the exact location is determined, your next step is to calculate the effective diameter of the damaged area. The effective diameter of the damaged area is based on the shape of the damage in relation to the 50-percent chord/0° fiber reference line. The 50-percent chord line and 0° fiber reference line are both the same. Figure 3-28 shows examples of how the length, width, and diameter (rounded damage) come into play when determining the effective diameter of a damaged area.

Patch Material Selection. Once you have pinpointed the exact location of the damage and determined the effective diameter, it is time to select the proper titanium foil patch required or to obtain information related to the number and sizes of the plies needed for a graphite-epoxy pre-preg fabric repair. The shape of the patch required is determined by the shape of the damaged area.

Titanium foil patch. For purposes of this discussion, let's assume that the following is the repair data you have to work with:

- Damage is on a flat surface of a vertical stabilizer.
- Damage is located at water line (WL) 183.50.
- Damaged material composition is boron.
- Damage effective diameter is 1½ inches.
- Damage area calls for a round patch plate.

Armed with these facts, you must now locate in the -3 technical order the part number of the titanium foil patch plate for the damaged area. Make sure that during research you select the table that corresponds to the shape of the patch required—either round or oval.

Figure 3-29 is the chart you would first consult, based on your repair data. To use this chart, you first go down through the listing of water line number ranges until you come to the area for your damage (WL 183.50). Once you have located the correct water-line range, you can proceed across the chart until you come to the column representing the diameter of your damage. Based on our repair data, the number of the patch plate needed is -2007. Doublecheck to see if this is correct. You then used this number (-2007) along with other numbers given in the -3 TO to order the patch plate from the manufacturer.

A description of the patch plate numbered -2007 is given in figure 3-30. The patch that you would be ordering is 8 inches in diameter, contains 5 plies, weighs 0.34 pounds, and is 0.082 inch thick. Take a few minutes and briefly look over some of the other patch descriptions shown.

Graphite-epoxy pre-preg fabric. For the purpose of this discussion, let's assume that the following is the repair data you have to work with:

a. Damage is on a curved surface of a graphite composite (speedbrake structure).

b. Damage is located in zone H of this structure (refer to fig. 3-27).

c. Damage effective diameter is 3/8 inch.

d. Damage area calls for an oval patch.

Based on this repair data, the first place you would go to is the graphite fabric oval patch selection chart (see fig. 3-31). The two items needed to use this chart are the zone location of the damaged area and the effective diameter of the damage. By cross-referencing the zone location H and the diameter of the damaged area (3/8 inch), you come up with a patch number of GR-8.

At this time, you then turn to the patch layup sequence chart (see fig. 3-32). To use this chart, you find your particular patch number (GR-8) and directly across from it is given the sequence of plies required. In our case, the sequence is P-22, P-21, P-20, P-19, P-18, P-17. A total of six plies are required for this repair. Now that you have the number callouts for the individual plies (P-20, etc.), your next step is to find out the sizes of the required plies andhow they are laid up in relation to the 0° fabric line of the damaged component.

Figure 3-33 illustrates the chart needed to obtain that information of sizes and layup direction. For callouts given for our repair, the sizes of the oval plies needed range from 9.5 x 6.3 (P-22) to 7.6 x 4.4 (P-17). Also, note that the end radii are equal to one-half the distance of the width. As for the layup directions (warp orientation, degrees), the last column of the chart provides this information. The first ply (P-22) is laid up at a plus 45°, the next two plies (P-21 and P-20) at 0°, the fourth ply (P-19) at a minus 45°, and the last two plies (P-18 and P-17) at 0°. This layup sequence will return the damaged area to its original load-carrying requirement.

Exercises (861e):

NOTE: Refer to the figures within this objective segment as needed.

1. If the damaged area is on the flat surface of a graphite-epoxy composite structure, what type of patch material would you be using?

2. If the prefabricated titanium round patch required for a damage between water lines 219.000 and 248.00 on the vertical stabilizer was numbered -2015, what would be the maximum size of the damaged area?

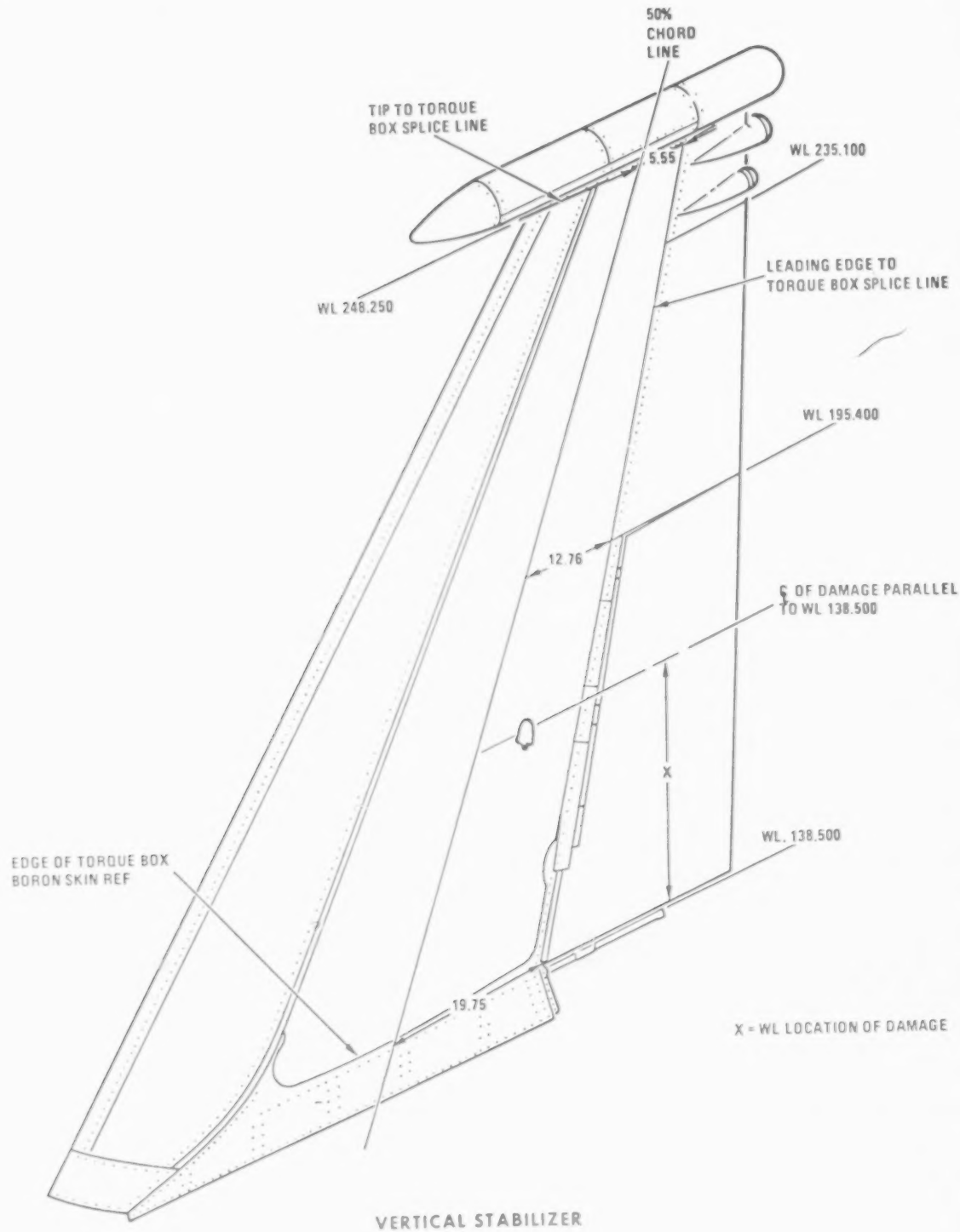


Figure 3-25. Vertical stabilizer—boron composite skin and aluminum honeycomb core.

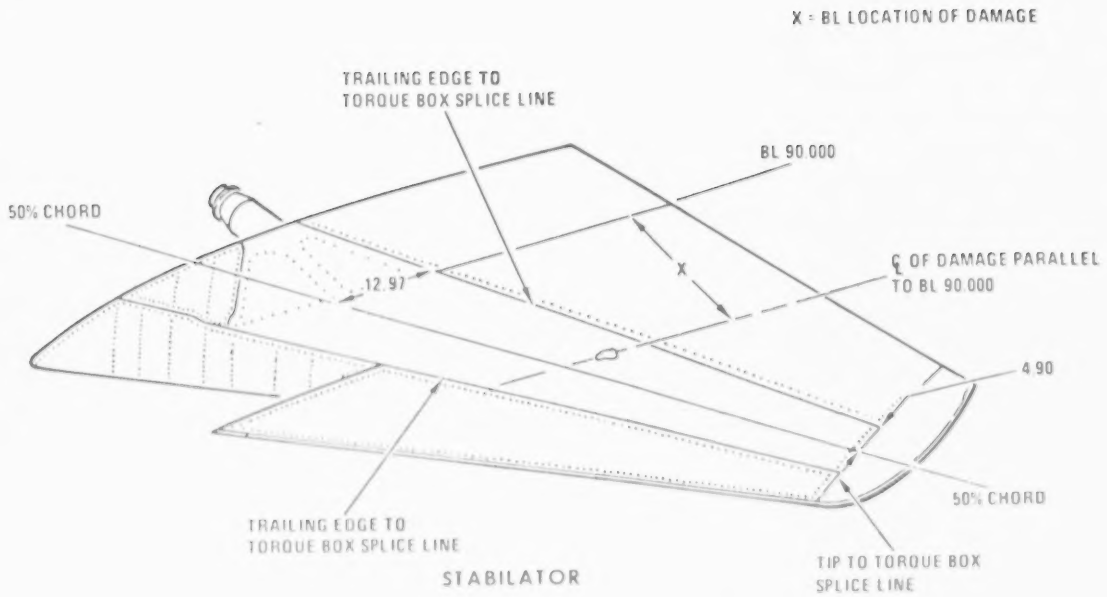


Figure 3-26. Stabilator—boron composite skin and aluminum honeycomb core.

3. How many plies of graphite-epoxy pre-preg fabric cloth would be needed to patch a 1⅞-inch oval damage on the curved surface area of a graphite structure, with a zone callout of "A"?

4. Based on your answer to question 3, what is the size of the largest ply and in what direction is it laid up?

5. What would be the weight and thickness of a prefabricated oval titanium foil patch that is number coded -2027?

861f (Objectives 905—for computer answer key and feedback reference only). Specify the safety and working practices to follow when removing damaged materials from boron or graphite composite structures.

Once you have determined the type, shape, and size of the patch materials needed, you are now ready to remove the damaged materials. The removal procedures and the tools that you will use are quite different from those used on conventional bonded structures. But before getting into these tools, it is best that you first become acquainted with the safety practices that must be employed when working with damaged boron or graphite-epoxy materials.

Safety Factors. Earlier it was mentioned that extra care was needed when working with boron or graphite composite materials because of the inherent danger (filament penetration) involved through mishandling. This same added caution also applies when grinding, drilling, and sanding these materials.

The following is a list of safety precautions you should become familiar with to protect yourself and your fellow workers when working with these materials:

a. Loose particles of boron filaments must be carefully disposed of to prevent injury.

b. Avoid carrying boron filaments to other areas on shoes, clothes, shop towels, etc., where they can contaminate other materials and cause later injury. Clothing should be of a tight-weave with a smooth surface fabric finish to prevent filament penetration.

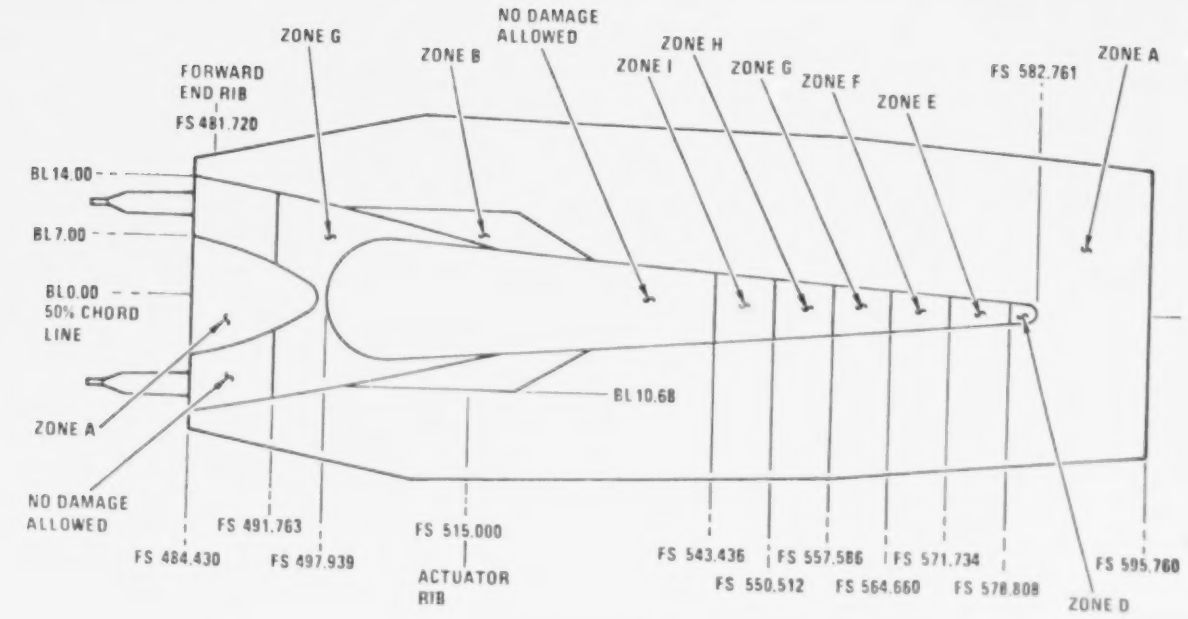
NOTE: If an exposed boron filament does penetrate your clothes and enter the skin, remove it endwise by using a tweezer. Attempts to remove it flatwise will cause it to fracture into small fragments.

c. Eye protection devices must be used when grinding, drilling, and sanding.

d. Gloves must be worn when handling composite materials.

e. Dust mask and hat must be worn when grinding or sanding, since the fine dust produced may cause skin irritation. Breathing an excessive amount of this dust material is harmful.

Damage Removal Tools. It is extremely important that you use only removal tools that have been specifically designed for boron or graphite-epoxy



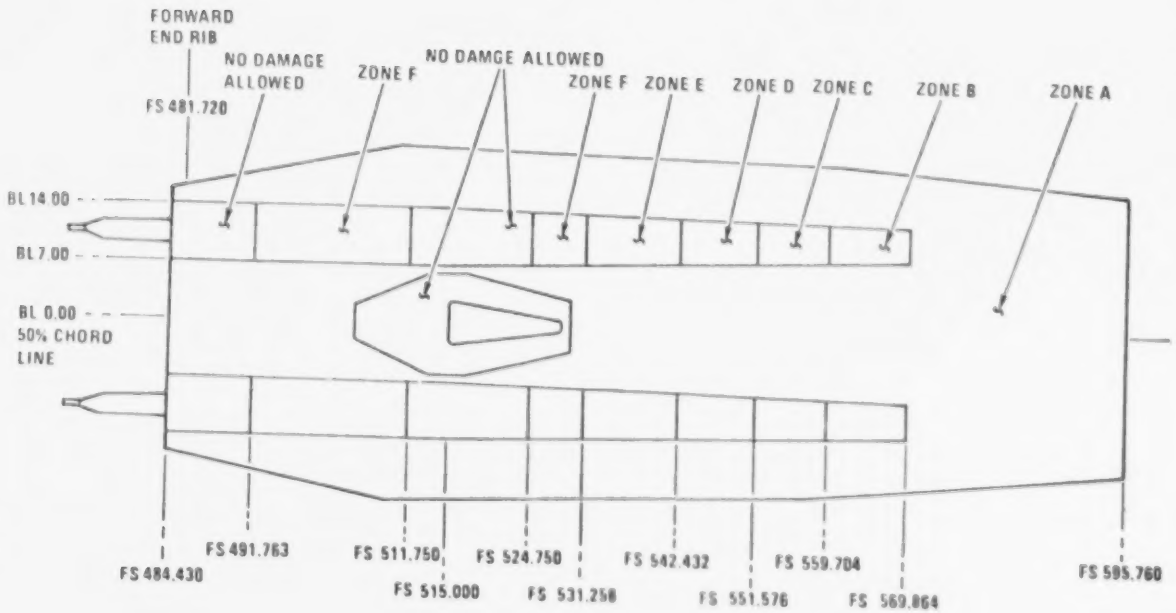
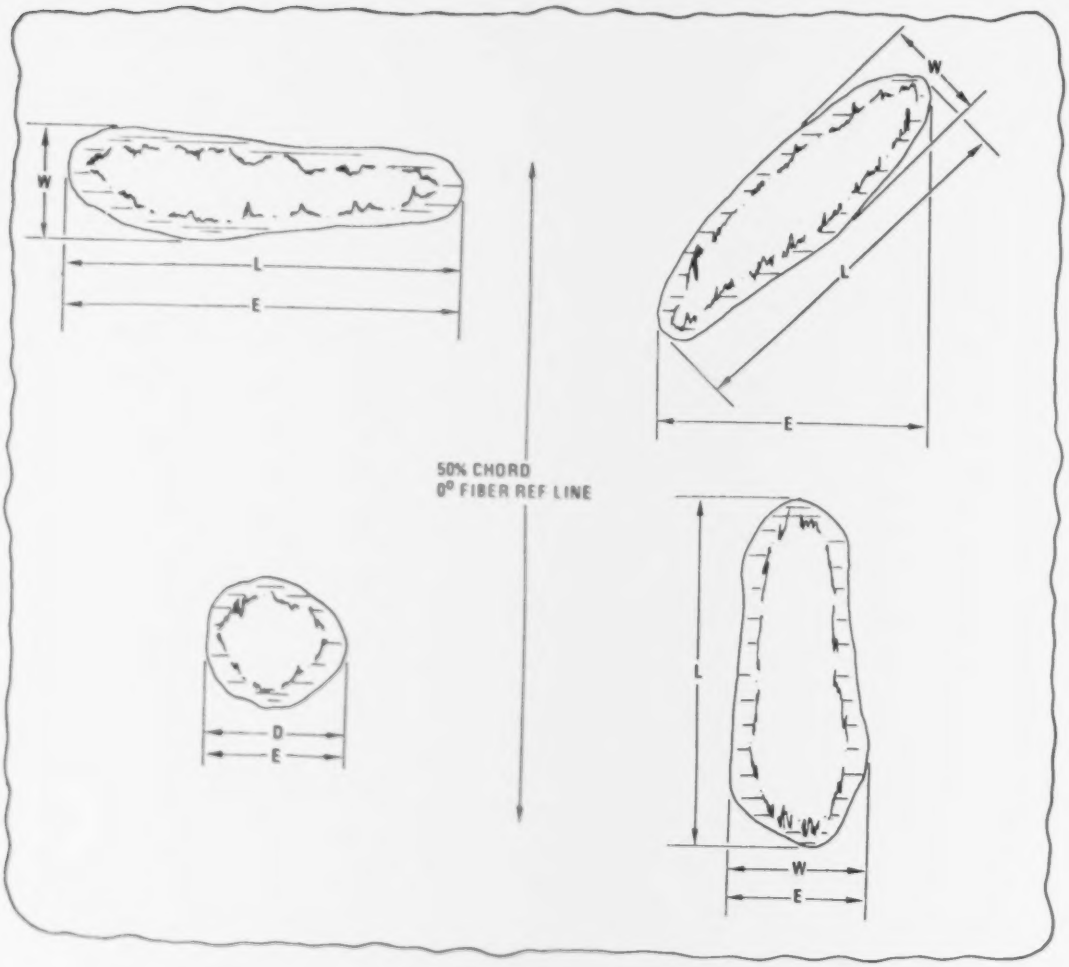


Figure 3-27. Speed brake zone diagram—graphite composite skin and aluminum honeycomb core.



LEGEND

W	DAMAGE WIDTH, 3.0 MAXIMUM
L	DAMAGE LENGTH: VERTICAL STABILIZER AND STABILATOR, 6.0 MAXIMUM SPEED BRAKE, 3.0 MAXIMUM
D	DIAMETER OF ROUND DAMAGE IS EQUAL TO E
E	EFFECTIVE DIAMETER OF DAMAGE MEASURED PERPENDICULAR TO 0° FIBER LINE. REFER TO TEXT FOR LIMITS.

Figure 3-28. Determining effective diameter of damage.

[1] Location		[5] Patch Number						
Water Line		[2] Diameter of Damage						
From	To	0 to 1/8	[3] 0 to 1/8	1/8 to 1/2	1/2 to 3/4	3/4 to 1.0	1.0 to 2.0	2.0 to 3.0
153.00	163.00	-2015	-2001	-2003	-2005	-2005	-2011	-2013
163.00	173.00	-2015	-2001	-2003	-2005	-2005	-2011	-2013
173.00	183.00	-2017	-2015	-2001	-2003	-2005	-2009	-2011
183.00	193.00	-2017	-2015	-2001	-2003	-2005	-2007	-2011
193.00	219.00	-2017	-2015	-2001	-2001	-2003	-2005	-2009
219.00	248.00	-2017	-2017	-2015	-2001	-2001	-2005	-2007

[1] To determine water line location of damage, see figure 3A-1.

[2] To determine effective diameter of damage, see figure 3A-4. Maximum allowable effective diameter is 3.0 inches.

[3] This patch is used to cover two or more holes. Patch must extend beyond holes a minimum of 1 inch from each hole, or holes shall be patched separately.

[4] If damage occurs in this area, consult the applicable ALC engineering for disposition.

[5] Patches are details of K000012-1001 Composite Assemblies Field Repair Parts Patch Kit. For patch description, see figure 3A-6.

Figure 3-29. Vertical stabilizer titanium patch selection—round.

materials. The use of conventional tools will not only damage them, but you will most likely cause additional damage to the composite component being repaired.

Special composite materials repair kits, like the one shown in figure 3-34A, are needed when boron or graphite composite materials are being repaired. A description of the tools and how each is used is contained in figures 3-34B and 3-34C. Take a few minutes and briefly go over the descriptions of the various tools to get an idea of just what is available in these kits. The diamond tipped tools can be used for both boron or graphite materials, whereas the carbide tipped tools are for use on graphite material. In later objective segments, you will see how these tools come into play during repair procedures.

Damage Removal Guidelines. The cardinal rule to follow when removing damaged materials from boron/or graphite materials is to remove only the damaged area. Material that has not been damaged will be left in place, regardless of the shape that remains. The examples of surface cutouts shown in figure 3-35 strongly illustrate this point. The only requirements that must be followed when making a surface cutout, regardless of the shape, are that corner radii must be at least 1/16 inch in diameter and the edges of the cutout must be beveled from 15° to 30°.

The cutouts illustrated in figure 3-35 are made only when the damage is completely through all outer plies or when the damage is completely through the composite assembly (both sides). When only the top or first couple of plies are damaged, do not attempt to shape the damaged area into any particular shape. The only things removed are the broken filaments, after which the edges of the damaged area are sanded to a 15° to 30° bevel.

When removing frayed or damaged honeycomb core materials, conventional tools (knife, tweezers, etc.) can be used. But remember, remove only the damaged core material. If the opposite side bond line is still intact and the core material isn't damaged all the way to the opposite side, do not remove the entire portion. Since the cutout area will be filled in with a filler compound, the remaining portions of honeycomb core within the cutout area provide additional bonding surfaces. Proper removal of the damaged core material will provide an adequate undercut around the under surface of the cutout area. A vacuum cleaner should be used to insure that all traces of the damaged materials are removed from the cutout area.

Chart Selected Patches				
[1] Patch No.	Size (Inches)	Number of Plies	Weight (Pounds)	Thickness (Inches)
ROUND PATCHES				
-2001	4.0	3	0.07	0.054
-2003	6.0	3	0.12	0.054
-2005	6.0	5	0.20	0.082
-2007	8.0	5	0.34	0.082
-2009	8.0	7	0.40	0.110
-2011	10.0	8	0.72	0.124
-2013	12.0	10	1.43	0.152
-2015	3.0	2	0.023	0.040
-2017	2.5	1	0.01	0.026
OVAL PATCHES				
-2019	7.0 x 4.0	3	0.12	0.054
-2021	9.0 x 6.0	3	0.23	0.054
-2023	9.0 x 6.0	5	0.34	0.082
-2025	11.0 x 8.0	5	0.50	0.082
-2027	11.0 x 8.0	7	0.66	0.110
-2029	13.0 x 10.0	8	1.00	0.124
-2031	15.0 X 12.0	10	2.0	0.152
SQUARE PATCH				
-2033	4.0 x 4.0	1	0.033	0.026

[1] Patches are details of K000012-1001 Composite Assemblies Field Repair Parts Patch Kit.

Figure 3-30. Titanium prefabricated patch description.

[2] Diameter of Damage (Inches)	[3] Patch Number / [1] Repair Zone A	B	C	D	E	F	G	H	I
0 to 1/4	GR-5	GR-5	GR-5	GR-5	GR-5	GR-6	GR-6	GR-6	GR-7
1/4 to 1/2	GR-5	GR-5	GR-6	GR-6	GR-7	GR-7	GR-8	GR-8	GR-8
1/2 to 3/4	GR-5	GR-5	GR-6	GR-7	GR-8	GR-8	GR-8	[4]	[4]
3/4 to 1.0	GR-5	GR-6	GR-7	GR-8	GR-8	[4]	[4]	[4]	[4]
1.0 to 1 1/4	GR-5	GR-6	GR-7	GR-8	[4]	[4]	[4]	[4]	[4]
1 1/4 to 1 1/2	GR-5	GR-7	GR-8	[4]	[4]	[4]	[4]	[4]	[4]
1 1/2 to 1 3/4	GR-5	GR-7	GR-8	[4]	[4]	[4]	[4]	[4]	[4]
1 3/4 to 2.0	GR-6	GR-8	[4]	[4]	[4]	[4]	[4]	[4]	[4]
2.0 to 2 1/4	GR-6	GR-8	[4]	[4]	[4]	[4]	[4]	[4]	[4]
2 1/4 to 2 1/2	GR-6	GR-8	[4]	[4]	[4]	[4]	[4]	[4]	[4]
2 1/2 to 2 3/4	GR-7	GR-8	[4]	[4]	[4]	[4]	[4]	[4]	[4]
2 3/4 to 3.0	GR-7	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]

[1] To determine repair zone location of damage, see figure 3A-3.

[2] To determine effective diameter of damage, see figure 3A-4. Maximum allowable effective damage is 3.0 inches.

[3] To determine patch lay-up sequence see figure 3A-8.

[4] Consult the applicable ALC engineering for disposition.

Figure 3-31. Graphite fabric oval patch selection.

Patch No	[1] Ply Number						
GR-2	P-8	P-7	P-6	P-5			
GR-3	P-11	P-10	P-9	P-8			
GR-4	P-11	P-10	P-9	P-8	P-7	P-6	P-5
Oval Patches							
GR-5	P-15	P-14	P-13	P-12			
GR-6	P-19	P-18	P-17	P-16			
GR-7	P-22	P-21	P-20	P-19			
GR-8	P-22	P-21	P-20	P-19	P-18	P-17	P-16

[1] For patch ply geometry, see figure 3A-9. Patches are laidup with the largest ply next to mold line surface.

Figure 3-32. Graphite fabric patch layup sequence.

Exercises (861f):

1. With regard to clothing, how can filament penetration be reduced?

2. When is it necessary to wear eye protection when working with boron composites?

3. What is the main thing to remember when removing damaged materials from boron or graphite composite structures?

4. What factors must be incorporated into a cutout on boron or graphite composite structure, regardless of the shape of the cutout?

5. How is the required undercut obtained when making cutouts on boron or graphite composite structures?

6. What shape should the damaged area look like, if only the top few plies are damaged?

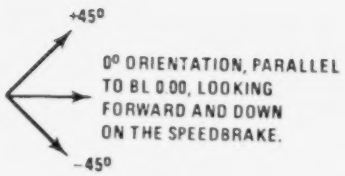
7. Why is the use of conventional removal tools not recommended for boron or graphite composite structure cutouts?

8. If a piece of boron filament does penetrate your skin, how should it be removed?

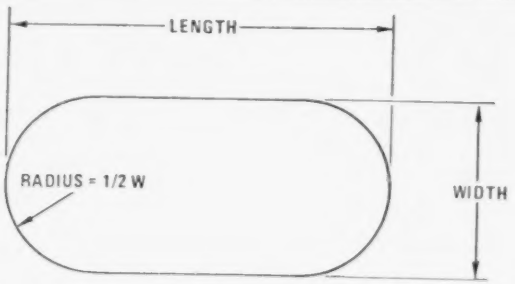
861g (Objective 906—for computer answer key and feedback reference only). State important factors concerned with the repair procedures related to negligible damage surface rework and surface ply delaminations of boron or graphite composite structures.

Not all repairs you will make will have a damage removal step. Damages such as negligible surface defects and surface ply delaminations are just two of this type. However, the critical nature of these repairs should not be overlooked by the fact that there isn't any "damaged" material to be removed. The overall important factor of strength requirement must be maintained in any repair situation. The following repair procedures will quickly point this out to you.

Negligible Surface Rework. Negligible surface damages are confined to minor cuts, scratches, pits, erosion, abrasion, and dents. Specific -3 technical orders will spell out the exact limitation for these damages. For purposes of our discussion, let's assume that you are required to repair a dent on a boron-epoxy



ROUND PLY GEOMETRY		
PLY NO.	DIAMETER, INCHES	WARP ORIENTATION, DEGREES
P-1	2.5	-45°
P-2	2.9	0°
P-3	3.3	0°
P-4	3.6	+45°
P-5	4.0	+45°
P-6	4.4	0°
P-7	4.8	0°
P-8	5.1	-45°
P-9	5.5	0°
P-10	5.9	0°
P-11	6.3	+45°



OVAL PATCH LAYOUT

OVAL PLY GEOMETRY		
PLY NO.	LENGTH X WIDTH INCHES	WARP ORIENTATION, DEGREES
P-12	5.7 X 2.5	-45°
P-13	6.1 X 2.9	0°
P-14	6.5 X 3.3	0°
P-15	6.8 X 3.6	+45°
P-16	7.2 X 4.0	+45°
P-17	7.6 X 4.4	0°
P-18	8.0 X 4.8	0°
P-19	8.3 X 5.1	-45°
P-20	8.7 X 5.5	0°
P-21	9.1 X 5.9	0°
P-22	9.5 X 6.3	+45°

Figure 3-33. Graphite fabric patch layup orientation.

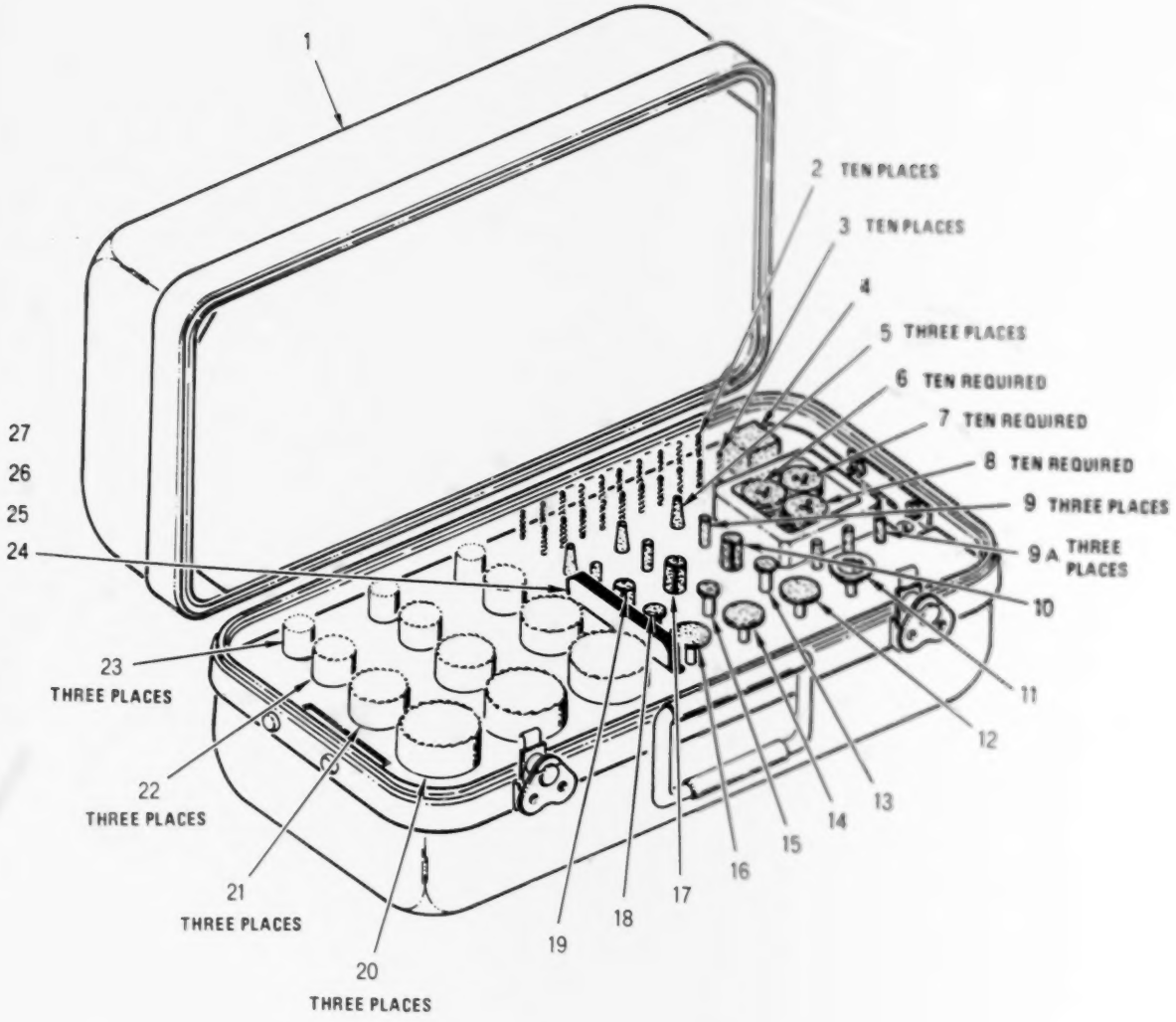


Figure 3-34A. Composite material repair kit (sheet 1 of 3).

Idx No.	Nomenclature and Part No.	Function
1	Case 68D050071-2001	Contains composite material repair tools.
2	Mounted Cylinder, 1/8-inch Dia MDP-601 MD	To drill injection holes in boron composite skins. Use with 1,000 RPM drill motor.
3	Carbide Drill, 1/8-inch Dia CAD-402 MD	To drill injection holes in graphite composite skins. Use with 1,000 RPM drill motor.
4	Dressing Stone DS-601 MD	To clean diamond cutters, routers, and core drills. Dress tools at operational RPM.
5	Router, 1/8 to 1/4-Inch Dia DR-203 MD 60-80	Fine routing of irregular shaped boron composite skin damage. Use with 20,000 RPM router motor.
6	Sanding Disc SD-702 MD 60	Coarse sanding. Use with 1,000 RPM drill motor.
7	Sanding Disc SD-702 MD 120	Medium sanding. Use with 1,000 RPM drill motor.
8	Sanding Disc SD-702 MD 240	Fine sanding. Use with 1,000 RPM drill motor.
9	Router, 1/4-Inch Dia DR-202 MD 60-80	Smooth routing of irregular shaped boron composite skin damage. Use with 20,000 RPM router motor.
9A	Router, 1/4-inch Dia CR-701 MD	Coarse routing of graphite composite skins. Use with 20,000 RPM router motor.
10	Router, 1/2-Inch Dia DR-201 MD 120	Fine routing of irregular shaped boron composite skin damage. Use with 20,000 RPM router motor.
11	Sanding Disc Holder SDH-701 MD	To hold sanding discs while sanding.
12	Mounted Wheel, 1 Inch Dia MW-102 MD 120	Fine cutting of boron composite skins. Use with 20,000 RPM router motor.
13	Mounted Wheel, 1/2-Inch Dia MW-101 MD 120	Fine cutting of boron composite skins. Use with 20,000 RPM router motor.
14	Mounted Wheel, 1 Inch Dia MW-102 MD 80	Medium cutting of boron composite skins. Use with 20,000 RPM router motor.
15	Mounted Wheel, 1/2-Inch Dia MW-101 MD 80	Medium cutting of boron composite skins. Use with 20,000 RPM router motor.
16	Mounted Wheel, 1 Inch Dia MW-102 MD 40	Coarse cutting of boron composite skins. Use with 20,000 RPM router motor.
17	Router, 1/2-Inch Dia DR-201 MD 80	Medium routing of irregular shaped boron composite skin damage. Use with 20,000 RPM router motor.
18	Mounted Wheel, 1/2-Inch Dia MW-101 MD 40	Coarse cutting of boron composite skins. Use with 20,000 RPM router motor.
19	Router, 1/2-Inch Dia DR-201 MD 40	Coarse routing of irregular shaped boron composite skin damage. Use with 20,000 RPM router motor.

Figure 3-34B. Composite material repair kit (sheet 2 of 3).

Idx No.	Nomenclature and Part No.	Function
20	[1] Core Drill, 2 Inch Dia CD-304 MD	To remove circular boron composite skin damage. Use with 500 RPM drill motor.
21	[2] Core Drill, 1 1/2-Inch Dia CD-303 MD	To remove circular boron composite skin damage. Use with 500 RPM drill motor.
22	[3] Core Drill, 1 Inch Dia CD-302 MD	To remove circular boron composite skin damage. Use with 1,000 RPM drill motor.
23	[4] Core Drill, 3/4-Inch Dia CD-301 MD	To remove circular boron composite skin damage. Use with 1,000 RPM drill motor.
24	Template, 0.781 Inch Dia Hole 68D050071-2017	To guide 3/4-inch core drill. Secure template to repair skin with masking tape.
25	Template, 1.031 Inch Dia Hole 68D050071-2019	To guide 1 inch core drill. Secure template to repair skin with masking tape.
26	Template, 1.531 Inch Dia Hole 68D050071-2021	To guide 1 1/4-inch core drill. Secure template to repair skin with masking tape.
27	Template, 2.032 Inch Dia Hole 68D050071-2023	To guide 2 inch core drill. Secure template to repair skin with masking tape.

[1] Use with detail 27.
[2] Use with detail 26.
[3] Use with detail 25.
[4] Use with detail 24.

Figure 3-34C. Composite material repair kit (sheet 3 of 3).

composite panel. The major repair steps you would follow are:

a. Using abrasive paper (400 grit), blend the damaged area and remove the surface finish around the blended area.

NOTE: Use extreme care when sanding not to break any filaments. If any filaments are broken, then you must go to a different class of repair.

b. Wipe the area clean with a clean, dry cheesecloth.

NOTE: Do not touch sanded area with bare hands. Improper bonding can result if the oil on your hands is placed on the cleaned surface. You should wear clean, cotton gloves to prevent this from happening.

c. Brush apply one or more coats of compound EA 956 to fill in the dented area and restore the surface mold line, as shown in figure 3-36.

NOTE: EA 956 compound is a structural adhesive (epoxy resin) used as a seal coat to repair negligible damage of boron and graphite skins. It has a worklife of 40 minutes.

d. Cover wet compound with Mylar film and work out entrapped air bubbles.

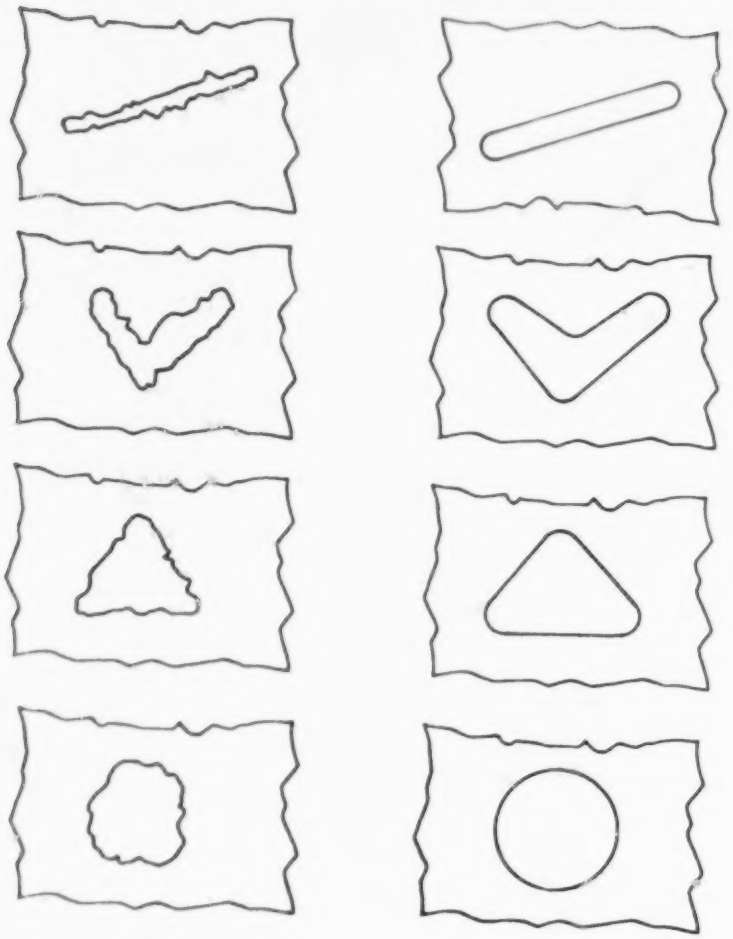
e. Cure repaired area and refinish surface as required.

Surface Ply Delaminations. These repairs are somewhat more involved than the negligible rework procedures. Repair procedures for surface ply delaminations are shown in figure 3-37. For purpose of our discussion, let's assume you are repairing a delaminated surface skin area of 1 inch. The major steps in accomplishing this repair are as follows:

a. Using a 1/8-inch mounted cylinder (taken form the composite material repair kit, fig. 3-34A) in a drill motor with a drill stop attached, drill two holes into the skin, one at each end of the delaminated area. NOTE: The mounted cylinder must be started at approximately 45° angle to the surface; otherwise the mounted cylinder may run across the surface causing additional damages. Once the mounted cylinder is started, change the drilling angle to 90°.

b. Drill holes approximately 0.025-inch deep, after which you must perform a bubble check. A bubble check consists of inserting a sealing nozzle tip into each drilled hole. Make sure the nozzles fit tight. Attach a piece of surgical tubing to the threaded end of one of the nozzles and immerse the end of the tubing in water. On the other nozzle, attach a regulated source of air pressure. Once you have completed this set-up, apply 8 psi of air. If no air bubbles appear in the water, you need to drill further into the plies. Drill in increments

SURFACE DAMAGE TO SKIN



TYPICAL DAMAGED AREAS

TYPICAL REWORKED AREAS

FULL PENETRATION OF ONE OR BOTH SKINS

LEGEND

REMOVE MINIMUM AMOUNT OF MATERIAL REQUIRED TO CLEAN UP DAMAGED AREA, USING APPLICABLE TOOLS FROM COMPOSITE MATERIAL REPAIR KIT. SEE FIGURE 4-32A. MINIMUM CORNER RADIUS 1/16-INCH.

Fiugre 3-35. Removal of composite skin damage.

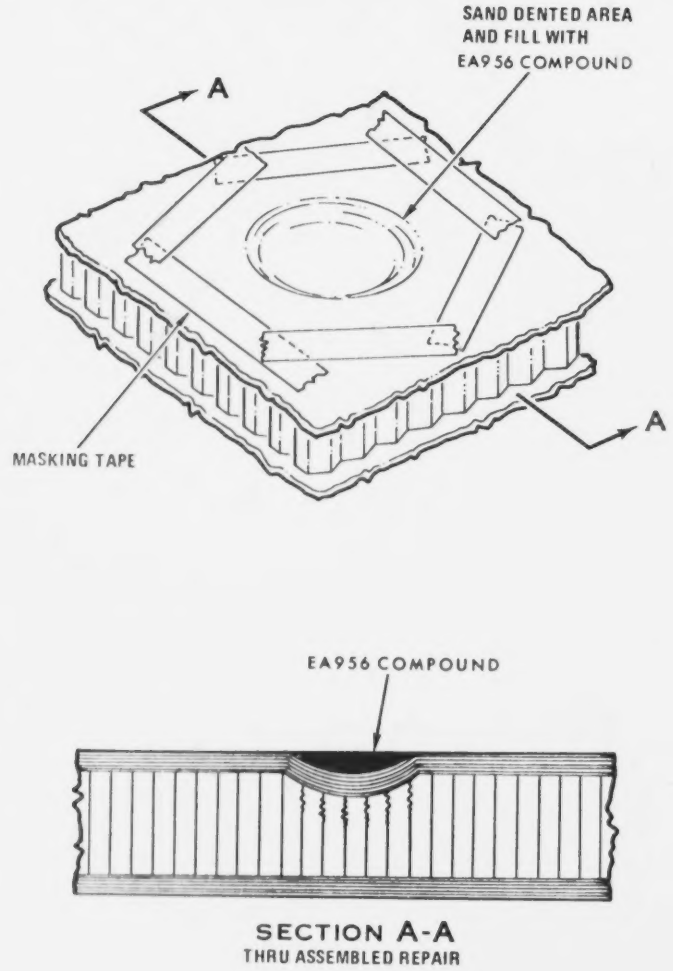


Figure 3-36. Negligible surface rework—dented area.

of 0.020 and perform a bubble check after each increment until the void is reached.

NOTE: Take care not to drill completely through the surface plies in the honeycomb core material.

c. Once the void is reached and you have cleaned the surface area, inject compound EA 956 into one of the holes until it flows out of the other hole.

d. Tape over drilled holes and cure injected compound EA 956.

NOTE: This is the first of three curing processes involving this repair.

e. Once the compound EA 956 is cured, or while it is being cured, you must now determine the proper size prefabricated titanium patch to use. Looking back to figure 3-29, you will notice that there are two 0-1/8-inch columns under the diameter of damage. The first 0-1/8-inch column is for repair situations involving only one hole. The second 0-1/8-inch column is the one required for two or more holes as indicated in note number 3, below the chart.

NOTE: Anytime you drill a hole in the surface of boron or graphite composite materials, it must be patched.

f. After determining the size of the patch required, remove enough of the surface finish around the damaged area so that it extends 1/2-inch around all sides of the installed patch. Sanding discs in the repair kit are used for this purpose.

g. Once the surface finish is removed, prime the sanded area and patch plate with primer BR-400. Spray apply a smooth uniform film of primer to the bonding surfaces. Continuously agitate the primer as it is being sprayed. A dried film thickness of 0.0001 to 0.0005 inch is required. If the primer contains lumps or shows signs of gelation, do not use it.

h. Cure the primer on both the patch and surface area.

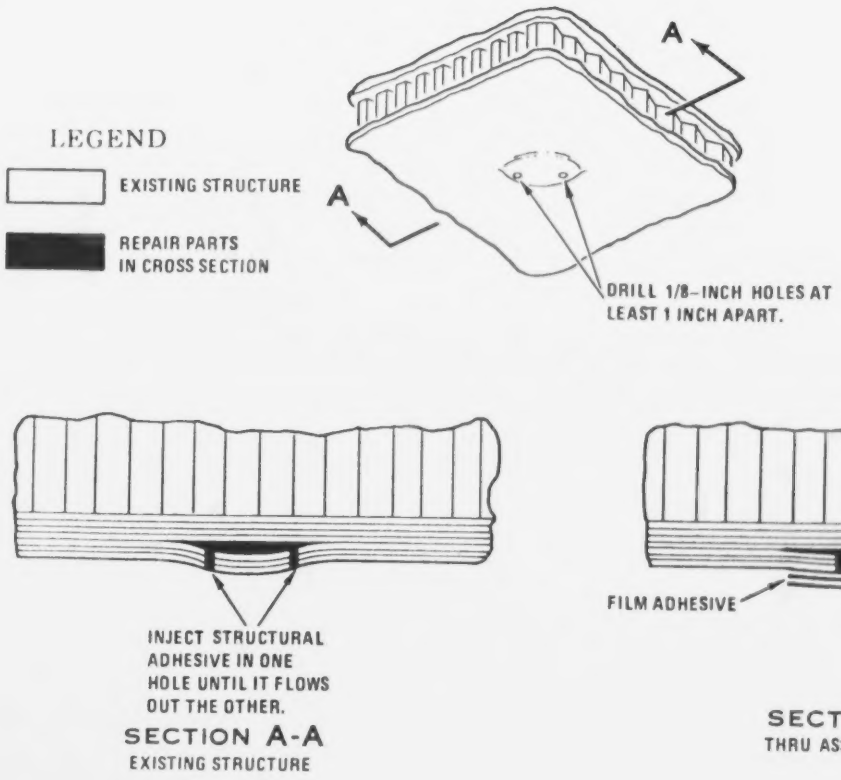


Figure 3-37. Surface ply delamination.

NOTE: This is the second curing step in this repair.

i. Apply one ply of FM-400 film adhesive to the primed side of the patch. The diameter of the film adhesive must be 1/4-inch greater than that of the patch.

NOTE: FM-400 film adhesive is a nylon fabric supported gray colored material. It is not a fire hazard but it is toxic. FM-400 must be allowed to warm up to room temperature in its plastic bag to prevent moisture absorption. Handle FM-400 film adhesive only while wearing clean, white cotton gloves.

j. Center patch plate over repair area and then cover patch with Mylar film. The film should overlap the patch by 1 inch on all sides.

k. Cure, repair, and refinish surface areas as needed.

NOTE: In repairs involving graphite, the edges of the cured patch are sealed with EA 956.

Exercises (861g):

1. What must be foremost in your mind when blending out minor surface defects on boron or graphite composite structures?
2. What type of personal equipment should you wear to prevent disbonds?
3. Besides filling in the dented area with the compound, what other factor must be restored?
4. Why is it necessary to start drilling at a 45° angle to drill a 90° hole, when using a mounted cylinder?
5. What is the purpose of a bubble check?
6. How much surface finish should be removed when installing titanium prefabricated foil patches?

7. What are the guidelines to follow when applying primer BR-400?

8. How large should the FM-400 adhesive film be in relation to the titanium foil patch plate?

861h (Objective 907—for computer answer key and feedback reference only). Supply informational details related to the repairs accomplished to boron and graphite composite structures involving ply-to-core disbonds and damaged honeycomb core materials.

The previously discussed repair procedures dealt mainly with surface damages. It is time now to look at what is done when the core material (honeycomb) is also damaged. This will be accomplished by looking at the repair procedures for disbonded areas (ply-to-core separation), and damages involving the core material, with one or both sides being damaged.

Ply-to-Core Disbonds. The main difference between this repair and that previously covered repair for ply delamination is that structural adhesive compound is injected into the core material. As for how the drilling is done and how much adhesive is injected, this depends on the position of the panel, whether it is in a horizontal or vertical plane, and whether the top or bottom skin area of the panel is being repaired. Figure 3-38 shows three possible repair situations—condition A, condition B, and condition C. Let's breifly look at these conditions and see how each differs from the other.

Condition A. This occurs when the panel being repaired is in a vertical position. The 1/8-inch holes are drilled at each end of the void at approximately 30° angles. The drilling must be started at 45°, then changed to 30° once the drilling starts to cut. The holes are drilled completely through the core material down to the backside of the opposite surface. Care should be taken not to drill into the opposite surface plies.

Structural adhesive, such as EA 956, is injected into the lower hole until the adhesive flows out of the upper hole. At that time, you will proceed to repair the area as discussed for the ply delamination.

Condition B. This occurs when the panel being repaired is in a horizontal position and you are repairing the top skin surface. The drilling procedure is the same as that used for the Condition A.

Condition C. This occurs when you are repairing the bottom skin surface of a panel in a horizontal position. The drilling procedure is different in that the holes are drilled straight up into the core material. The holes are not drilled completely through the core material. They are drilled only slightly past the inner surface ply into the area of the void. Once the injection process is completed, the repair is accomplished as for conditions "A" and "B."

NOTE: If more than two holes are needed for any of the conditions, a minimum spacing of 2 inches is required.

Honeycomb Core Damage Repairs. When the aluminum honeycomb core material of either a boron or graphite composite structure is damaged, it is always replaced with a core filler compound. This is quite a change from the procedure used on conventional metal bonded honeycomb assemblies, where replacement core material is used. The fact that most field authorized repairs are limited in size and that the cutout areas will be of various shapes and sizes, makes the use of a filler compound appropriate in such situations. Presently, the core filler compound recommended is EPO CAST 1310/Hn 9228. EPO CAST 1310 is the base material, while Hz 9228 is the catalyst. This compound has a worklife of 1½ hours.

Figure 3-39 and 3-40 show the repair procedures required when the original core material has been replaced with core filler compound and when either one or both sides of the panel have been damaged. Most of the repair procedures for accomplishing these repairs have been discussed earlier. Take a few minutes and briefly look at these figures and review the repair guidelines touched on.

The proper curing of the compounds and bonding adhesives used in these repairs, as well as earlier discussed repairs, is essential. Two methods of curing are permissible—the heat-blanket-vacuum method and the heat-blanket-stacked weight method, with the vacuum method being the preferred method. Figure 3-41 shows the set-up when a titanium patch is being bonded. When graphite-epoxy pre-preg patches are being bonded, the set-up is somewhat different, as you can see in figure 3-42. Specific guidelines for the set-up of each of these vacuum processes is given the -3 technical order. As for the cure time and temperature, a chart like the one shown in figure 3-43 is also found in the -3 TO. Vacuum should be applied slowly so that the patch material will flatten properly against the repair area. A minimum vacuum pressure of 24 HG (12 psi) should be continued on the vacuum bag during the complete curing time. Once the repair is cured, allow the repair area to cool to below 125° F before removing the vacuum pressure.

Besides the temperature control unit shown in figures 3-41 and 3-42, you will most likely have the honeycomb structure repair kit shown in figure 3-44. This repair kit contains tools, equipment, and materials required for honeycomb repairs. The tools include a heavy-duty router kit, a vacuum pump, sealant gun, potentiometer, and a combination vacuum-heating blanket. All electrical equipment is vaporproof and may be used on fueled aircraft.

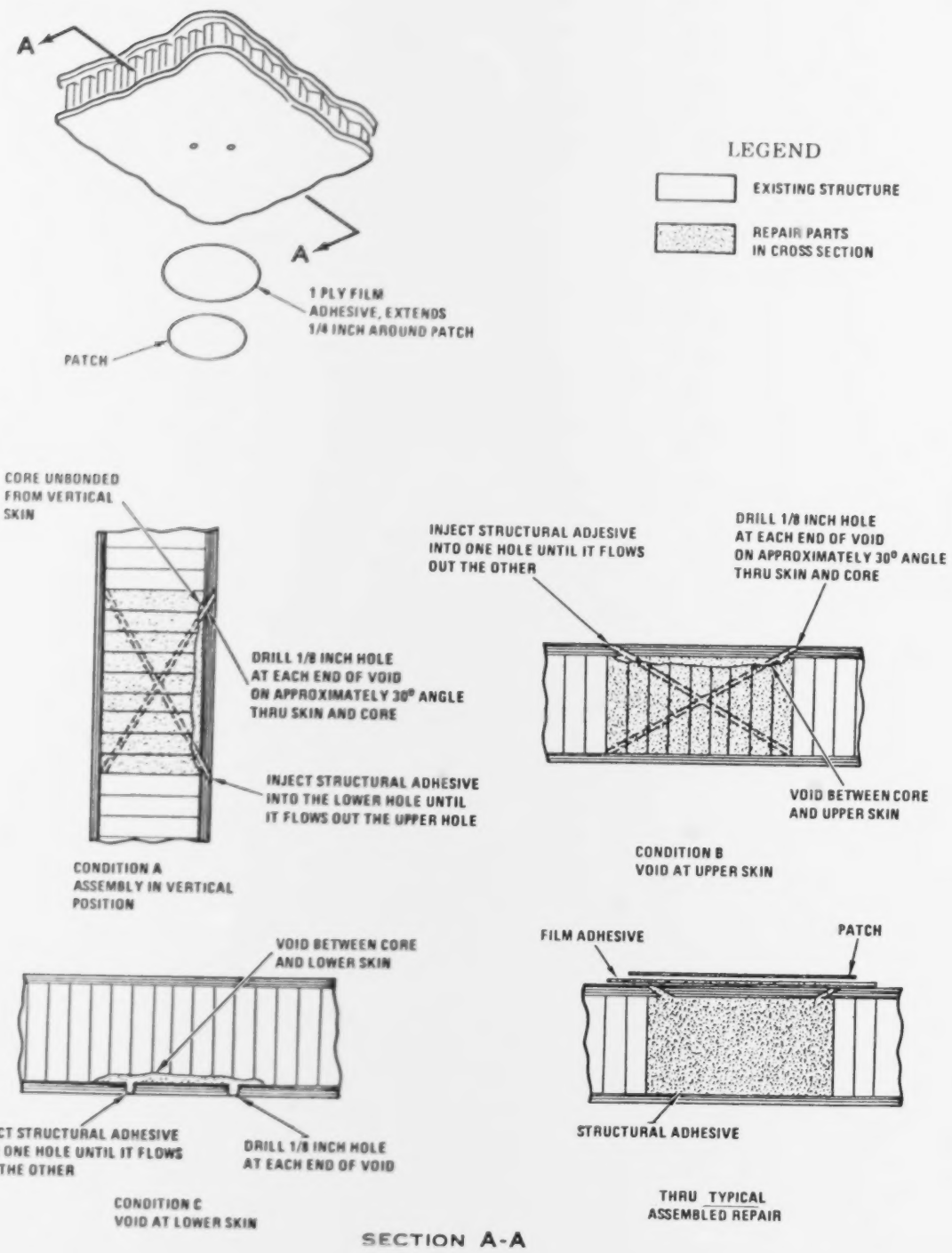

A
A
1 PLY FILM ADHESIVE, EXTENDS 1/4 INCH AROUND PATCH
PATCH
LEGEND
EXISTING STRUCTURE
REPAIR PARTS IN CROSS SECTION
CORE UNBONDED FROM VERTICAL SKIN
DRILL 1/8 INCH HOLE AT EACH END OF VOID ON APPROXIMATELY 30° ANGLE THRU SKIN AND CORE
INJECT STRUCTURAL ADHESIVE INTO THE LOWER HOLE UNTIL IT FLOWS OUT THE UPPER HOLE
CONDITION A ASSEMBLY IN VERTICAL POSITION
INJECT STRUCTURAL ADJESIVE INTO ONE HOLE UNTIL IT FLOWS OUT THE OTHER
DRILL 1/8 INCH HOLE AT EACH END OF VOID ON APPROXIMATELY 30° ANGLE THRU SKIN AND CORE
VOID BETWEEN CORE AND UPPER SKIN
CONDITION B VOID AT UPPER SKIN
VOID BETWEEN CORE AND LOWER SKIN
INJECT STRUCTURAL ADHESIVE INTO ONE HOLE UNTIL IT FLOWS OUT THE OTHER
DRILL 1/8 INCH HOLE AT EACH END OF VOID
CONDITION C VOID AT LOWER SKIN
FILM ADHESIVE
PATCH
STRUCTURAL ADHESIVE
THRU TYPICAL ASSEMBLED REPAIR
SECTION A-A

Figure 3-38. Ply-to-core disbonds.

95x

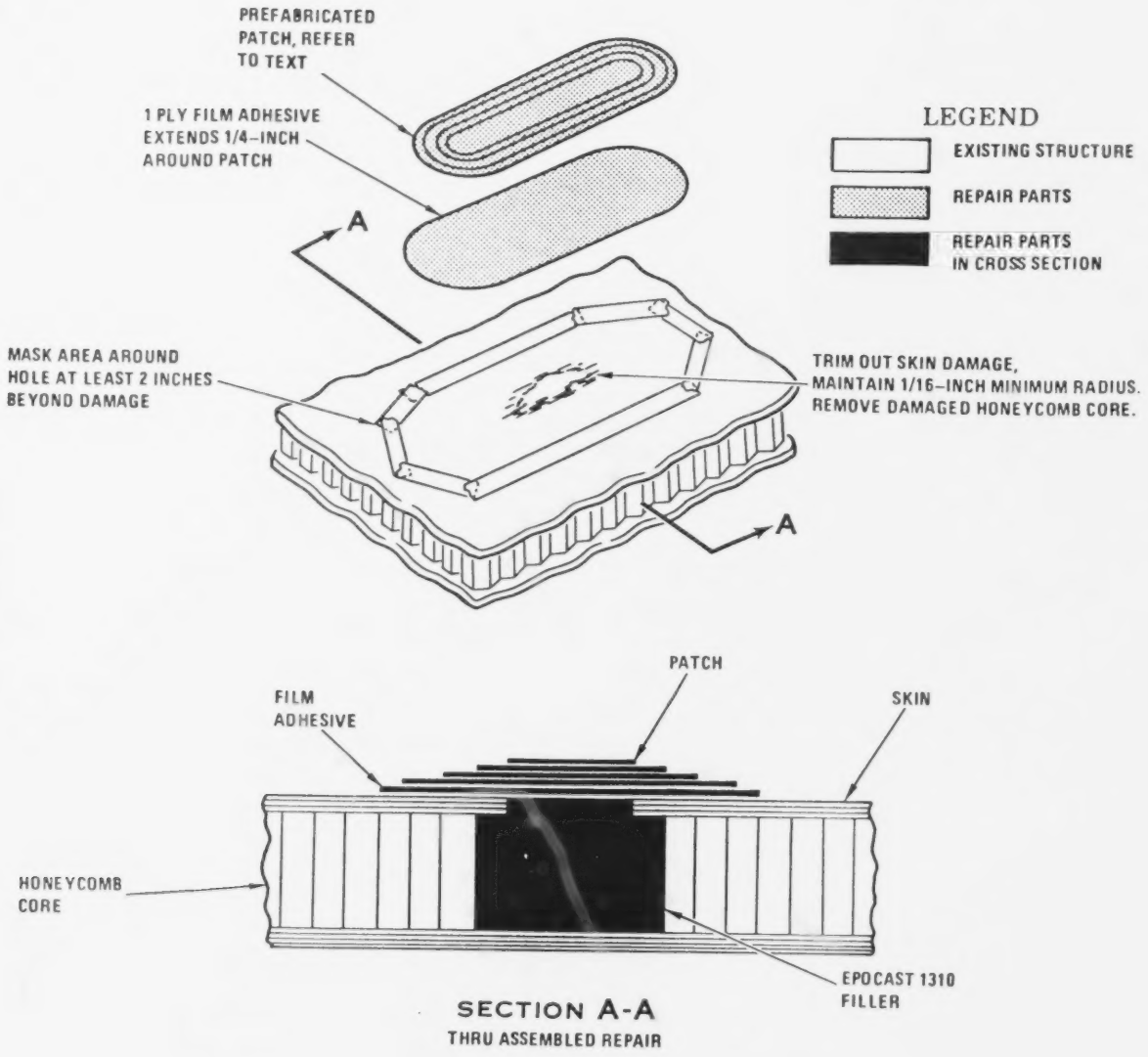


Figure 3-39. Single side and core damage—boron composite skin.

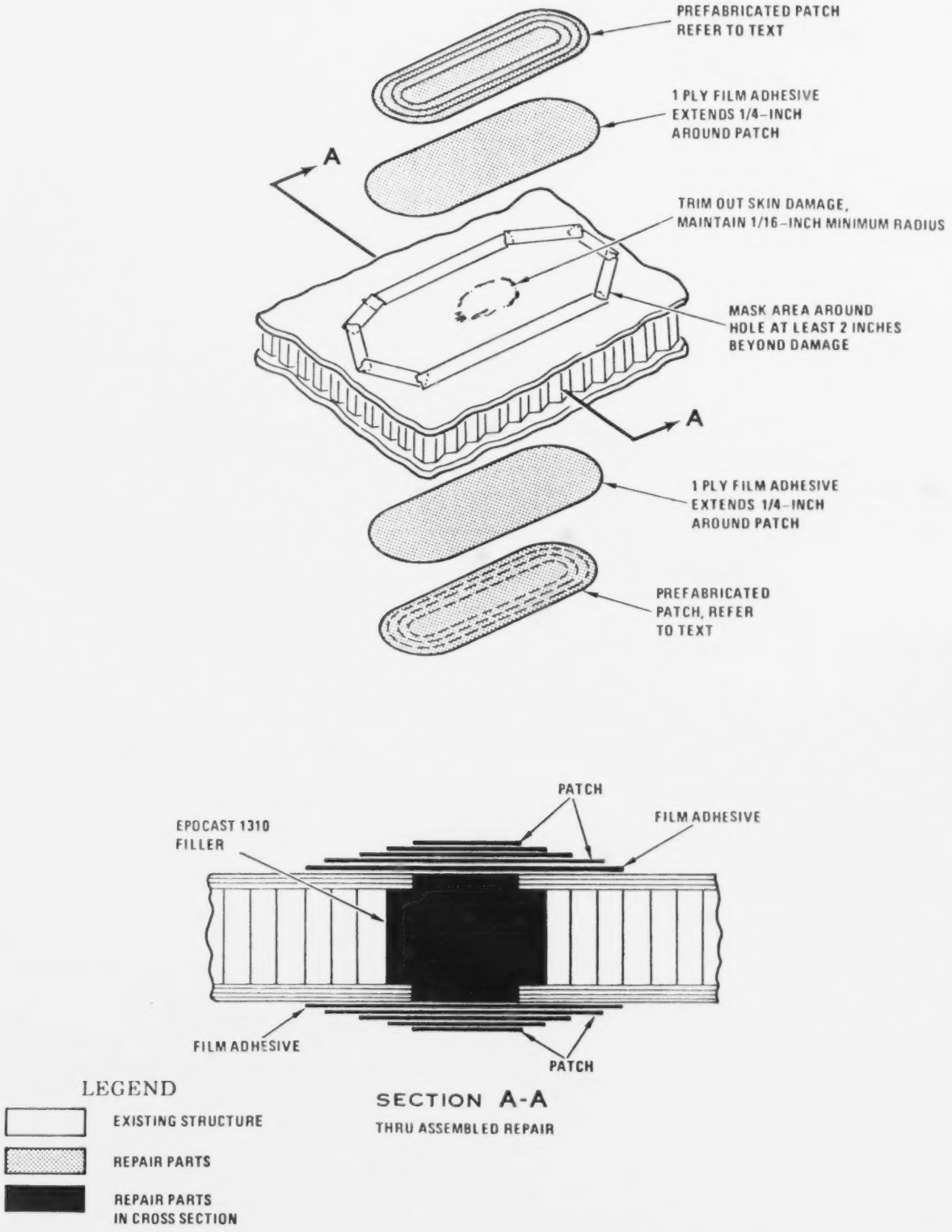


Figure 3-40. Both sides and core damage--boron composite skin.

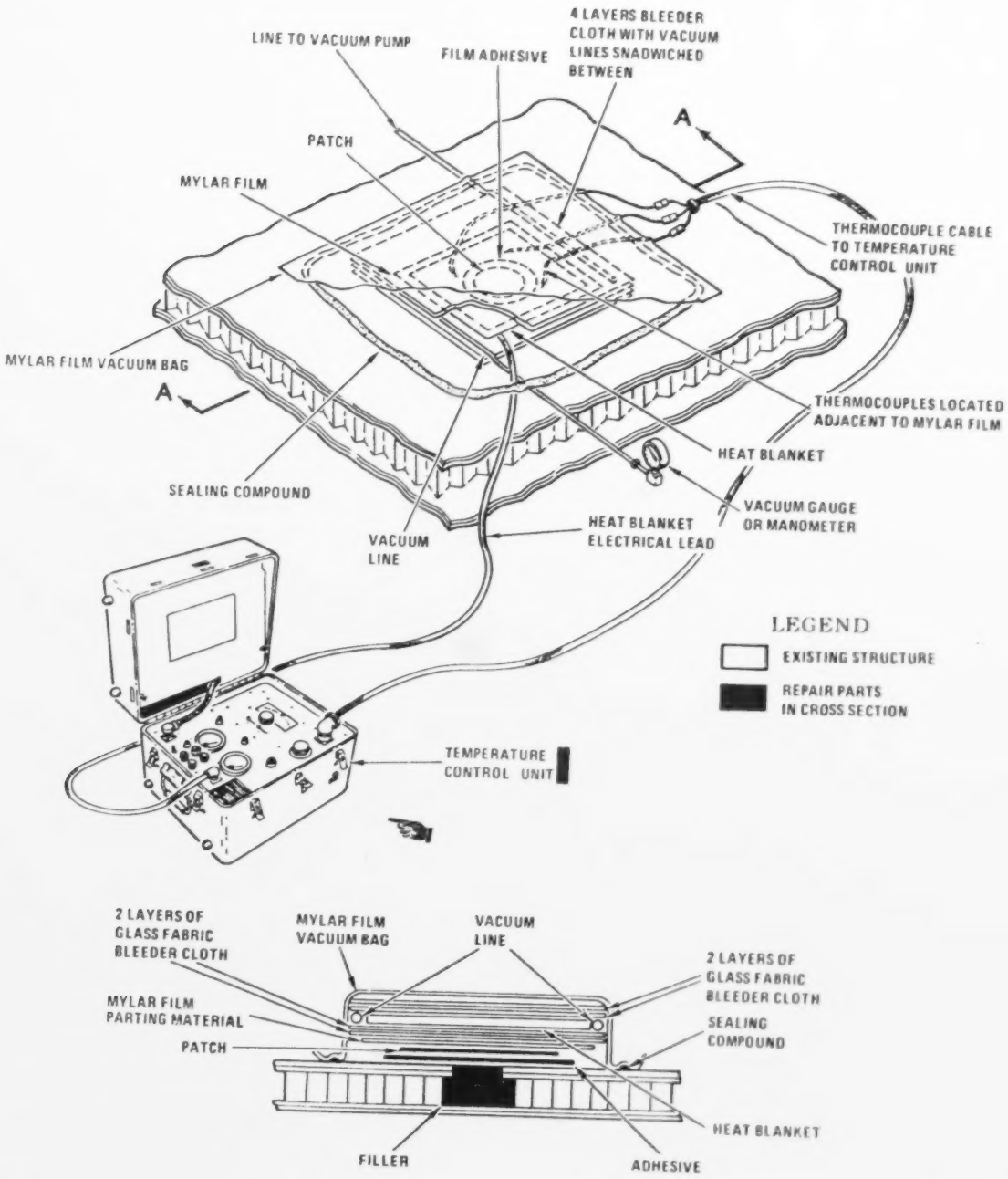


Figure 3-41. Vacuum-curing method for titanium.

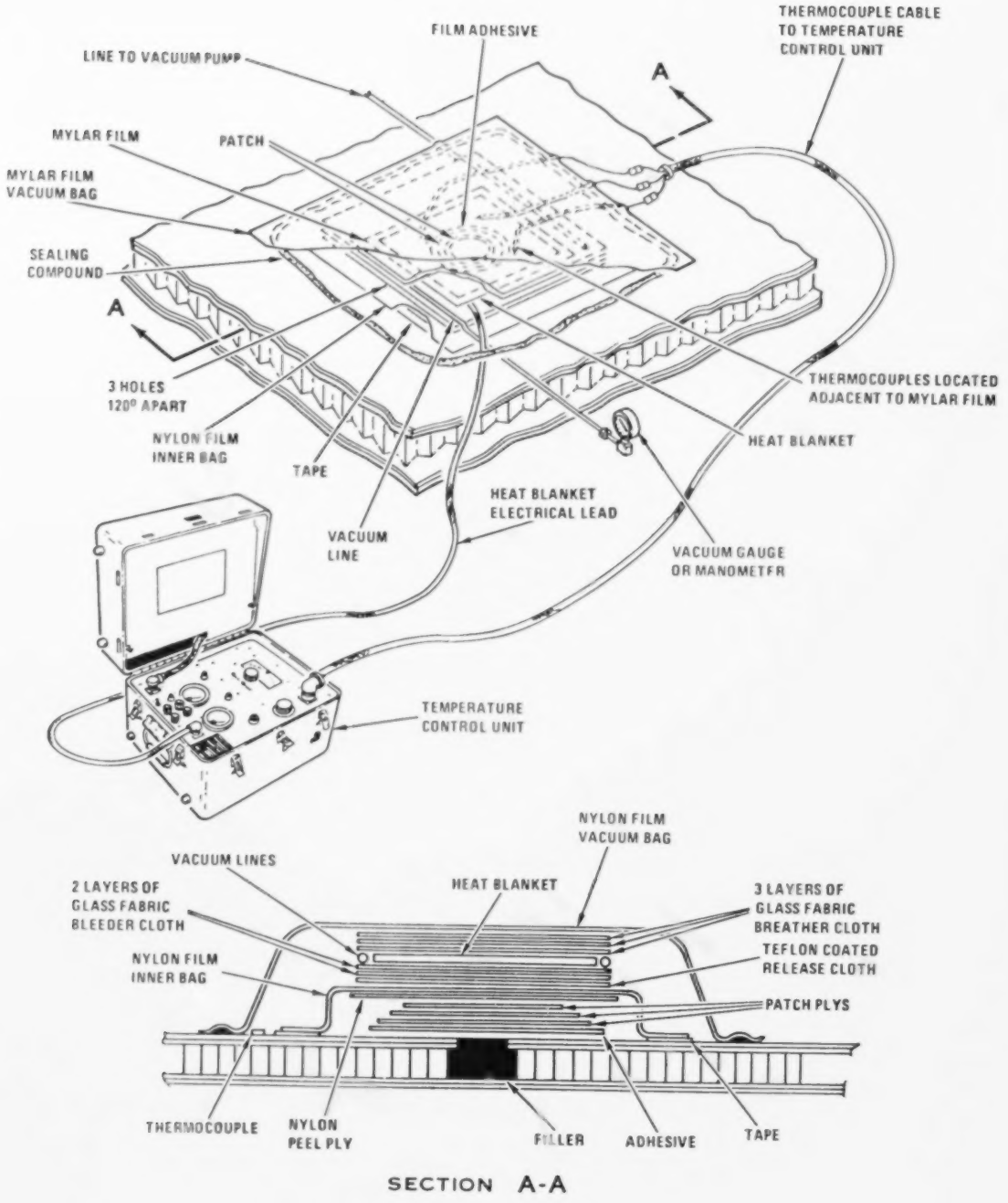


Figure 3-42. Vacuum-curing method for pre-preg patches.

Type of Structure	Class of Repair Material	Cure Time	Temperature
Aluminum Skin and Honeycomb Core	Class IV, V, VI, XII, and XV	2 Hours	240° to 260°F
Titanium Skin and Honeycomb Core	Class III and IV Temporary Repair	1 Hour	180° to 200°F
Vertical Stabilizer and Stabilator Boron Composite Skin and Aluminum Honeycomb Core	Class I, II, V, VI, and VII Class X	1 Hour 2 Hours	340° to360°F 325° to 335°F
Rudder Boron Composite Skin and Aluminum Honeycomb Core	Class IV, V, VI, and VII Class X and XI	1 Hour 2 Hours	340° to 360°F 325° to 335°F
Graphite Composite Skin and Aluminum Honeycomb Core	Titanium Patch Repair Graphite/Epoxy Patch Repair	1 hour [2]	340° to 360°F [2]
Reinforced Plastic	Polyester Alternate Resin EA934 Compound EA 956 Compound F-141-67-1581 Polyester Pre-preg Fabric F-161-83M-7781 Epoxy Pre-preg Fabric	1 Hour 1 Hour 1 Hour 1 Hour 2 Hours	240° to 260°F 180° to 200°F 180 ° to 200°F 340° to 360°F 325° to 335°F
[1] Deleted. [2] Gradually apply heat in 50° increments at 10 minute intervals until 350° ±10°F is obtained, maintain 350° ±10°F for 1 1/2 hours.			

Figure 3-43. Curing time and temperature.

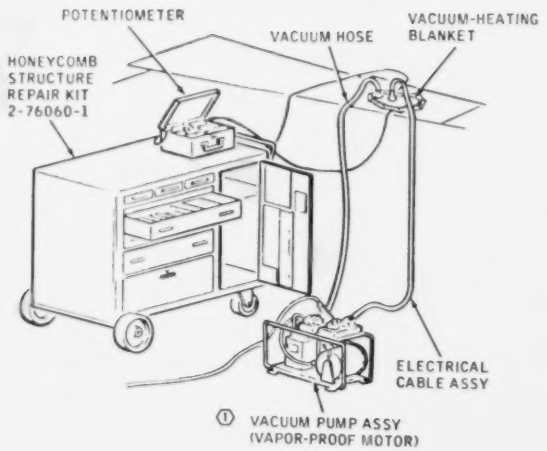


Figure 3-44. Honeycomb structure repair kit.

Exercises (861h):

1. What factor determines the direction of the holes drilled for a disbonded area on a boron composite structure?
2. How are the holes drilled for a vertical panel which has a 1-inch disbond?
3. What is used to replace damaged core material in boron or graphite composite structures?
4. What is the preferred method of curing boron composite repairs?
5. What factors must be remembered when applying vacuum to graphite and boron repairs?

CHAPTER 4

Aircraft Cables

WHEN AN AIRCRAFT has an engine failure or structural damage in midair, the pilot has a good chance of bringing the plane in safely. Failures in control cables, however, are much more serious, and the pilot had better start thinking of his parachute.

A part of your duties is the periodic inspection and repair (or replacement) or faulty control cables. Just as in the case of repairs you make on aircraft structures, all damaged control cables should be restored to their original condition—or as near the original condition as possible. Very often the job calls for a cable replacement: but, if replacements are not available, you may have to fabricate new control cables. While making such inspections and repairs, observe all safety precautions.

4-1. Features of Aircraft Cables

Aircraft cables, as you can see from the preceeding paragraphs, are a vital part of an aircraft. When repairs and replacements are needed, it is important that you select the correct type. This section is designed to give you the necessary facts you need when working with aircraft cables.

862. Specify advantages of using cable (instead of rods or tubing) assemblies in controlling aircraft systems.

Cable Uses. Cables are used on aircraft to operate and regulate control surfaces, escape hatches, life raft compartments, bomb bay doors, wheelwell doors, and engine accessories. Cables are used to tow gliders and targets; to release parachutes, bombs, and flares; to load ammunition and cargo; and to perform a number of essential maintenance functions, such as hoisting and towing.

Cables in aircraft control systems have part numbers and come prefabricated to fit from turnbuckle-to-turnbuckle or from turnbuckle-to-unit. Spare cable assemblies are not always available, so you may have to duplicate damaged ones.

Selection Factors. Many advantages are gained by the use of cables in aircraft. One of the more important advantages is that cable failure is seldom abrupt but instead is progressive over periods of extended use. They seldom break or sever even under strains such as those that occur during towing or hoisting. Cables are stronger than steel rods or tubing of the same size. They flex without setting and can easily be routed around obstacles with pulleys. Cables can be installed over long distances (a necessity in bombers) without a great degree of sagging. Vibration will not cause them to work-harden, as sometimes happens when either push-pull control rods or tubing is used.

When cables are used for the operation of a unit, they must be used in pairs—one set to move the unit one direction and the other to move it in the opposite direction. In spite of the need of a second set, weight is saved because a push rod needed to create a similar movement would be considerably heavier. Since cables are used in pairs and are stretched taut, very little play exists between the actuating device and the unit. Consequently, cable-controlled units respond quickly and accurately to cockpit control movements.

Exercise (862):

1. List six reasons why cable assemblies are used in aircraft.

863. Differentiate false from true statements related to aircraft cable assembly terms and construction features.

Cable Construction Terms. In order that you gain a fuller understanding of cable construction, the following definitions are given:

a. Wire – Each individual cylindrical steel rod or thread shall be designated as a wire.

b. Strand – Each group of wires helically twisted or laid together shall be designated as a strand.

c. Cable or wire rope – A group of strands helically twisted or laid about a central core shall be designated as a cable. The strands and the core shall act as a unit.

d. Preformed type – Cable consisting of wires and strands shaped prior to fabrication of the cable to conform to the form or curvature that they take in the finished cable shall be designated as preformed type.

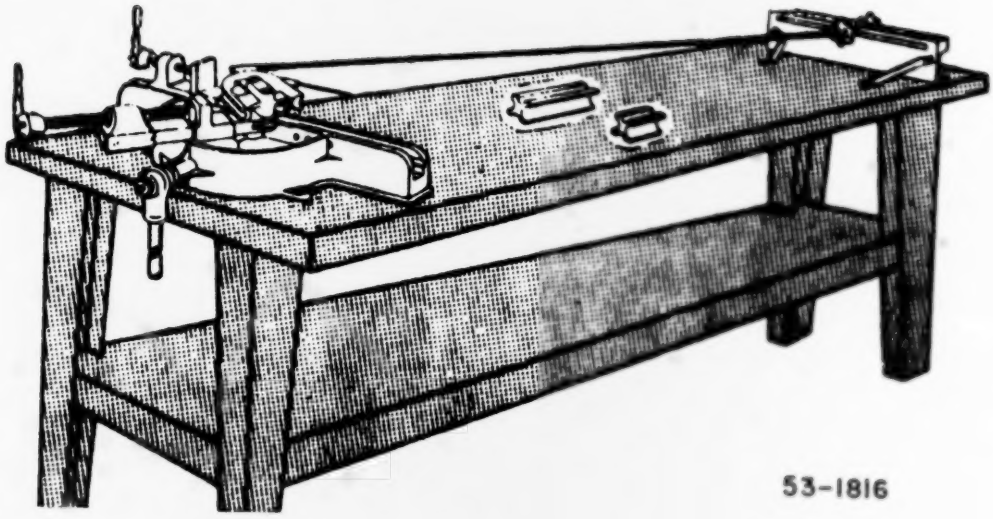


Figure 5-9. Production tube bender.

2. How is bending force applied to the tube when using a mechanical tube bender?

3. When is it necessary to use a mandrel when using a production tube bender?

4. To aid in producing a perfectly rounded tubing cross-section when using a production tube bender, what can you do?

5. How should the slide block be adjusted when using a production tube bender?

6. How should the clamp block be adjusted when using a production tube bender?

7. After each of the tubing defects listed, state the work procedure you would take to eliminate the problem when using a production tube bender.

   a. Tubing is flattened.

   b. Tubing is kinked.

   c. Tubing is wrinkled.

   d. Tubing separates upon bending.

878. Specify typical procedures to follow when using a filler material to aid in bending tubing.

When hand or production tube benders are not available or are not suitable for a particular bending operation, a filler of metallic composition or dry sand may be used to facilitate bending. When using this method, cut the tubing slightly longer than required. The extra length is for putting a plug (which may be wooden) in each end.

Metallic Composition Methods. This method involves the use of a fusible alloy. Prior to inserting the fusible alloy into the tubing, one end of the tubing is closed to prevent leakage of the fusible alloy. The tubing and ladle containing the fusible alloy is immersed in a tank of water at or near the boiling point until the alloy is melted. The melting point of the fusible alloy is 71° C. (160° F.). For ordinary tubing lengths, a hot water tank similar to that used in plating departments may be used. For longer lengths, a special tank may be constructed or a length of pipe

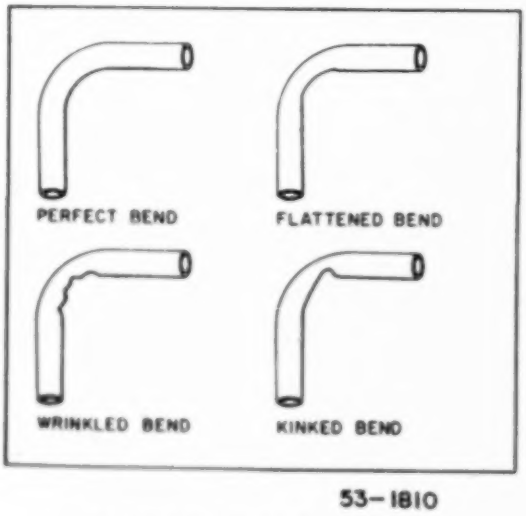


Figure 5-10. Tube bending requirements.

used so that both the tubing and the ladle will be completely submerged. When the fusible alloy has melted, pour it into the tubing. Keep both the tubing and the ladle beneath the surface of the hot water during the pouring operation so that the molten alloy will displace the water in the tubing. Remove the tubing from the hot water and cool it with cold water or allow it to air cool until the fusible alloy solidifies. The tubing can then be bent with a bending machine or blocks can be formed.

The fusible alloy should be cold when the tubing is being bent, and the tubing should be bent slowly. When the bending operation is completed, the fusible alloy can be removed from the tubing by immersing both the tubing and ladle in the tank of hot water and pouring the alloy back into the ladle. When pouring the alloy back into the ladle, keep both the tubing and ladle beneath the surface of the hot water, as this reduces the tendency of the alloy to stick to the inside of the tubing.

Never apply a torch or flame to tubing or fusible alloy, as excessive heat will destroy both the strength of heat-treated tubing and the melting characteristics of the fusible alloy. Boiling water will not melt fusible alloy after a flame has been applied. If a flame is used to remove the fusible alloy, particles of the alloy may stick to the inside of the tubing, causing corrosion.

Sand or Shot Method. In an emergency, aluminum alloy may be bent or formed by filling the tubing with shot or sand. After plugging one end, fill and pack the tube with fine, dry sand and plug tightly. Both plugs must be tight so they will not be forced out when the bend is made. The tube may also be closed by flattening the ends or by soldering metal discs in them. After the ends are closed, bend the tubing over a forming block shaped to the radius specified in the technical order. Make certain that all particles of the filler are removed after bending so that none will be carried into the system in which the tubing is installed.

Exercises (878):

1. When inserting a fusible alloy into a piece of tubing, how can you displace the water in the tubing?

2. How long should you wait after inserting the fusible alloy into the tubing before forming the tubing?

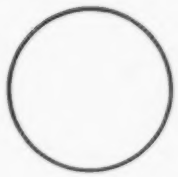
3. After the bending is accomplished using a fusible alloy, how is the fusible alloy be removed?

4. When using a filler material such as sand, to aid in bending tubing, how may the ends of the tubing be sealed?

878a (Objective 908—for computer answer key and feedback reference only). Explain significant details related to tubing flatness limitations; and based on given factors, determine the acceptability of a fabricated section of tubing.

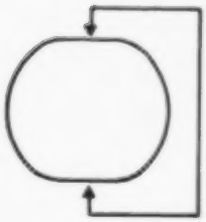
No matter which of the four methods you use to bend tubing, the uniformity (shape) of the bend radius and the ovality (flatness limitation) of the tubing material within the bend radius are just two of the many factors you will use to determine the acceptability (no-go-no) of a replacement piece of tubing. What to look for, as far as the uniformity of the bend radius goes, was clearly spelled out earlier (fig. 5-10), but what about this new item, the flatness limitation of the tubing material within the bend radius? Just what is this flatness limitation requirement that must be checked, why is it so critical, and how are measurements obtained for flatness determinations are just a few of the questions that will be answered in the following paragraphs.

Flatness Limitation Factors. Whenever a piece of tubing is bent, regardless of the method used to make the band and the number of degrees in the bend, the tubing material within the bend radius has a tendency to flatten out somewhat on two sides while the opposite sides expand outward. As the tubing flattens, it assumes the shape of an ellipse (oval) in cross-section, reducing the inside diameter area of the tubing. This flattening effect is illustrated in figure 5-10A. With the recent introduction of ultra-thin-wall (corrosion resistant steel 21-6-9) tubing materials and with more and more tubing being bent to their minimum bend radii, this flattening effect has become a critical factor in the fabrication of replacement parts of tubing assemblies. This flattening either reduces the amount of fluid actually delivered or causes additonal pumping power to overcome the increased line friction created by the flattened areas of the tubing walls.



TUBING DIAMETER

SHAPE BEFORE BENDING



FLATTENING EFFECT ON

TUBING DIAMETER SHAPE

AFTER BENDING

Figure 5-10A. Tubing flattening effect.

Since it is almost impossible to prevent this flattening effect from occurring under the conditions just mentioned, a certain amount of flatness is permitted, provided it falls within specific technical order limitations (TO 1-1A-8). The amount of flatness allowed depends upon the outside diameter (OD) of the tubing material before and after bending, and the working pressure (psi) within the tubing being replaced. Each of these items is interrelated, and a change of one has a direct effect upon the other in determining the allowable limitations, as you can see by looking at figures 5-10B and 5-10C. How each of these factors comes into play and the procedures used for determining the required measurements and flatness limitations are spelled out in the next paragraph.

Flatness Limitation Check Procedures. In order for you to perform a flatness limitation check, you need a pointed-type micrometer (threaded micrometer—Volume 2, fig. 3-21), a basic knowledge of working with decimals, an understanding of the elements called for within the flatness formula (fig. 5-10C), and lastly, the working pressure (psi) within the tubing section you are replacing. Armed with these facts, you should have no problems in determining the flatness limitation for a piece of bent tubing.

Since the care and usage of a micrometer, along with the procedures dealing with decimals, was covered in an earlier volume, our attention here will be focused on the three elements called for within the flatness formula—the maximum outside diameter (OD), the minimum OD, and the nominal OD. The maximum OD refers to the distance between the sides of the tubing that expand during the bending process, whereas the minimum OD refers to the distance between the flattened sides. The nominal OD is nothing more than the original (manufactured) OD before any bending has taken place. Figure 5-10D illustrates the determination points for these three elements. Once you obtain these needed measurements for the flatness formula, it is then just a matter of inserting these measurements into the formula and completing the required mathematical actions.

For example, let's assume that a replacement piece of tubing is 1/2 inch (.500) in outside diameter, has a working pressure of 1,500 psi with a wall thickness of .016, and requires a 90° bend. This statement alone gives you one of the formula elements—the nominal OD (.500). The remaining two elements are obtained after bending the tubing to the called for 90° bend radius. For purposes of our discussion, the maximum OD is .515 and the minimum OD is .495. Now that you have all three elements, insert them in the formula (fig. 5-10C) and proceed in the following sequence:

$$\frac{\text{(Max OD) } .515 - .495 \text{ (Min OD)}}{.500 \text{ (Nominal OD)}} = ?$$

$$(.515 - .495 = .020)$$

$$\frac{.020}{.500} \times 100 \text{ percent } (\%) = ?$$

$$(.020 \times .500 = .04)$$

$$.04 \times 100\% = 4\%$$

Based on our answer of 4 percent, and the limitation given in figure 5-10C related to the working pressure psi within the tubing system, the amount of flatness detected is permissible.

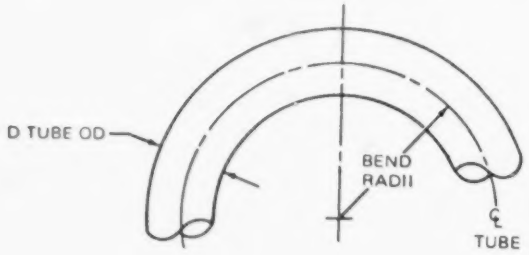
Exercises (878a):

1. What factors have increased the criticalness of performing a flatness limitation check?

2. What effect does the working pressure (psi) within a piece of tubing have on the flatness limitations?

3. Besides the working pressure (psi) within a piece of tubing, what other factor directly influences the amount of allowable flatness?

4. What factors are required in order to perform a flatness limitation check?



TUBE OD	SPECIAL BEND RADII SEE NOTE (a)		RECOMMENDED BEND RADII SEE NOTE (b)		ADDITIONAL BEND RADII SEE NOTE (c)
	1 - 1/2 D	2D	3D	4D	6D
1/8	.188	.250	.375	.500	.750
3/16	.281	.375	.563	.750	1.125
1/4	.375	.500	.750	1.000	1.500
5/16	.469	.625	.938	1.250	1.875
3/8	.563	.750	1.125	1.500	2.250
7/16	.656	.875	1.312	1.750	2.625
1/2	.750	1.000	1.500	2.000	3.000
5/8	.938	1.250	1.875	2.500	3.750
3/4	1.125	1.500	2.250	3.000	4.500
7/8	1.3125	1.750	2.625	3.500	5.250
1	1.500	2.000	3.000	4.000	6.000
1 - 1/8	1.688	2.250	3.375	4.500	6.750
1 - 1/4	1.875	2.500	3.750	5.000	7.500
1 - 3/8	2.063	2.750	4.125	5.500	8.250
1 - 1/2	2.250	3.000	4.500	6.000	9.000
1 - 5/8	2.438	3.250	4.875	6.500	9.750
1 - 3/4	2.625	3.500	5.250	7.000	10.500
1 - 7/8	2.813	3.750	5.625	7.500	11.250
2	3.000	4.000	6.000	8.000	12.000
2 - 1/4	3.375	4.500	6.750	9.000	13.500
2 - 1/2	3.750	5.000	7.500	10.000	15.000
3	4.500	6.000	9.000	12.000	18.000

Figure 5-10B. Radii allowance limitations.

(a) Use of special bend (1 - 1/2D to 2D) in fluid systems with working pressures of 1500 psi or greater require the approval of the system manager. Flatness, wrinkle and scratch requirements shall be as specified in notes (d) and (e).
(b) Recommended bends (3D and 4D) require no approval and shall be used wherever possible. Flatness, wrinkle and scratch requirements shall be as specified in notes (d) and (e).

(c) Additional bends (6D) shall be used only where fabrication or design difficulties preclude the use of recommended bends. Applications do not require specific approval and are limited only by the flatness, wrinkle and scratch requirements provided in notes (d) and (e).

(d) Flatness limitations

1. Flatness in the area of a tube bend shall be defined by the formula: Flatness = $\frac{\text{max. OD - min. OD}}{\text{nominal OD}} \times 100$ percent

2. Tube flatness for fluid systems with working pressures of 1,000 psi or greater shall not exceed 5 percent

3. Tube flatness for fluid systems with working pressures less than 1,000 psi shall not exceed 10 percent

(e) Wrinkles and scratches:

1. For fluid systems with working pressures 500 psi or greater, there shall be no wrinkles or kinks deeper than 1 percent of tube OD and no scratches deeper than 5 percent of the nominal wall thickness.

2. For fluid systems with working pressures of less then 500 psi there shall be no wrinkles or kinks deeper than 2 percent of tube OD and no scratches deeper than 10 percent the nominal wall thickness.

Bend radii for tube diameters other than those specified may be established by multiplying the tube outside diameter by the appropriate numerical prefix noted in the table for the class bend desired.

Figure 5-10C. Flatness and wrinkle factors.

5. Determine the acceptability of following two pieces of tubing based on the following data:

a. Tubing A:
   (1) Working pressure - 750 psi.
   (2) Max OD - .260.
   (3) Nom OD - .250.
   (4) Min OD - 3.20.
   (5) Wall thickness .016.
   (6) Bend radius 45°.

b. Tubing B:
   (1) Working pressure - 1,500 psi.
   (2) Max OD - .765.
   (3) Nom OD - .750.
   (4) Min OD - .735.
   (5) Wall thickness .025.
   (6) Bend radius 95° (2 each).

5-3. Flaring and Swaging of Aircraft Tubing and Fittings

The particular work procedure used to install tubing fittings will depend on the type fitting being used. For the flared-type (AN) fitting, the tubing must be flared, while the flareless type (MS) fitting is swaged on the tubing. Regardless of which type you are installing, you must follow specific guidelines to insure that, when the tubing assembly is installed on the aircraft, the fittings properly seal the tubing.

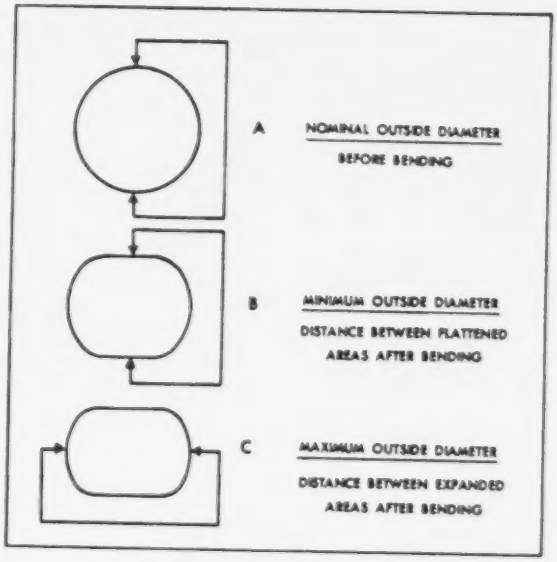


Figure 5-10D. Measurement points for flatness formula.

879. From a list of statements about tubing flares, identify the true statements and explain why the others are not correct.

Two kinds of flares are generally used in aircraft tubing systems, the single flare and the double flare. Either kind may be used when you use a three-piece solderless (AN) union. Because every three-piece (AN) fitting requires a flare and is used only in critical places, correct tube flaring is important. Flares are frequently subjected to extremely high pressure; therefore, the flare on the tubing must be properly shaped or the connection will leak or fail. Although incorrectly formed flares may seem to mate up satisfactorily and pass initial pressure tests, they are not to be depended upon for continuous service. To insure proper seating, the flare should conform to requirements of the fitting being used for connecting the tubing.

853 - 1. The size of the dent.
853 - 2. The hooked end acts as a pulling force to straighten the dent skin from inside the panel.
853 - 3. Only through the skin area.
853 - 4. Placement of the clear plastic base over the mandrel.
853 - 5. The mandrel is pulled upward.
853 - 6. Usually a potting compound is injected into the drilled holes, filling the void created in the core. Then either a metal or glass cloth overlay is added.

854 - 1. To aid in the adhesive flow between the skin and core.
854 - 2. To keep from drilling into the core materials.
854 - 3. To allow the adhesive to form a maximum bond line.
854 - 4. To avail trapping air between the skin and core.
854 - 5. To permit angle delivery if more convenient.
854 - 6. To eliminate stress concentrations at the ends of the crack.
854 - 7. To provide at least 1½ inch overlap on both sides of the cutout.
854 - 8. To speed up the drying.

855 - 1. Drill a small hole at a low point and check for water seepage.
855 - 2. It should be conducted for eight hours, at temperatures between 150° F. to 180° F.
855 - 3. A router should be used.
855 - 4. The hole should be drilled or cut at least one inch from the assembly end and two inches from the extremely trailing edge.
855 - 5. The vacuum pressure should be no more than 20 inches Hg; the temperature should be maintained at 180° for a period of one hour.
855 - 6. When 90 percent of the water has been removed and no dense pockets are present.

856 - 1. b. Lightly sand surface of the aluminum skin with 400 grit abrasive.
e. Prepare plastic sheets.
f. Position the thinner plastic sheet on bottom side.
j. Prepare potting compound.
l. Remove air bubbles.
n. Remove plastic sheets.
856 - 2 b. Position overlap in place.
d. Test for proper bond.

857 - 1. a. False.
b. True.
c. True.
d. False.
e. True.
f. True.
g. False.
h. False.
i. True.
j. False.

857 - 2. a. All core replacement repairs require overlays.
d. Glass cloth replacement core plugs are cleaned with MEK.
g. Aluminum replacement core plugs are cut 0.0156 larger than the cavity.
h. The cavity cells are also "buttered" with potting compound.
j. Foam tape adhesive is also applied to the cells of the cavity.

858 - 1. a. No.
b. No.
c. No.
d. No.
f. No.
858 - 2. a. Reverse the words "length" and "width."
b. Delete the remaining portion of the statement starting with "cell etc." Insert the following "thickness and material of the honeycomb panel skin."
c. Delete the words "equal to" and insert "0.004 to 0.006 of an inch thicker than" after the word "be."
d. Change "120" to "180."
e. Insert the word "not" between the words "is removed."

859 - 1. Flush repair.
850 - 2. Combination repair.
859 - 3. Nonflush repair.
859 - 4. Combination repair.
859 - 5. Combination repair.
860 - 1. Original size - 4½" by 5¼", New size - 5½" by 5¼".
860 - 2. Maximum size - 8 inches wide, 9½ inches deep.

861 - 1. The aircraft must be jacked to a jig position.
861 - 2. The work area should be cleared of all objects that could cause additional damage. Rivet shavings and bits and pieces of rivets should be thoroughly removed from padded surfaces where honeycomb panels will be placed.
861 - 3. Be careful not to damage or elongate mounting holes on the aircraft structure.
861 - 4. Inspect the panel for signs of damages received during shipment.
861 - 5. They should be drilled at the aircraft after the panel has been fitted to the aircraft opening.

CHAPTER 3A

861a - 1. Any six of the following would be correct:
a. Diminishing natural and energy resources.
b. Cost less to manufacture.
c. Have high-strength-to-weight ratio.
d. Abundant supply of raw materials are available.
e. High impact resistance.
f. A service temperature range from 350° to 400° F.
g. High deterioration resistance.
h. Excellent fatigue and corrosion resistance qualities.
861a - 2. Three factors:
a. Continuous filaments such as boron or graphite.
b. Improved resin matrix materials.
c. The concept of crossplied laminates.
861a - 3. It is the number of plies and their individual layup angles in relation to the first ply laid up.
861 - 4. The resin matrix functions as follows:
a. Stabilizes the filaments against compression instability.
b. Loads and unloads the filaments at their ends.
c. Carries transverse loads in individual layers.
d. Provides the body to the composite in its cured state.
e. Protects the filaments from abrasion.
f. Prevents the filaments from dropping.
861a - 5. The filaments are the primary load-carrying element.

861b - 1. B.
861b - 2. G.
861b - 3. G.
861b - 4. B, G.
861b - 5. B.
861b - 6. G.
861b - 7. B.
861b - 8. G.
861b - 9. B.
861b - 10. B, G.

861c - 1. a. False. Normally nonflush patches are allowed.
b. False. The main reasons for using titanium are its expansion characteristics, strength, stiffness, and weight.
c. False. Titanium foil patches are designed for use on flat surfaces.
d. False. Graphite-epoxy pre-preg patches are used only for graphite composite structures, not boron.
e. True.

f. False. An autoclave unit is needed to make titanium patch plates and is not needed to accomplish a graphite epoxy pre-preg fabric patch.

861d - 1. Coin-tapping method.
861d - 2. The coin-tapping method is good only for thin skin areas.
861d - 3. Whether or not a filament is broken.
861d - 4. By having the NDI specialist inspect the area.
861d - 5. Have the NDI specialist inspect the area for signs of moisture.

861e - 1. Titanium-foil patch plate.
861e - 2. 1/2 inch.
861e - 3. Four plies.
861e - 4. 6.8 × 3.6, +45° layup direction.
861e - 5. Weight 0.66, thickness 0.110.

861f - 1. By wearing tight-weave clothing with a smooth surface fabric finish.
861f - 2. Whenever grinding, drilling, or sanding.
861f - 3. Remove only the damaged material—nothing else.
861f - 4. The corner radii must be at least 1/16 inch and the sides must be beveled between 15° and 30°.
861f - 5. By proper removal of any damaged or frayed honeycomb materials.
861f - 6. Just the shape of the damaged area.
861f - 7. Because they will become useless and will cause additional damage.
861f - 8. Endwise, using a tweezer.

861g - 1. Not to break any of the composites' filaments.
861g - 2. Clean, white cotton gloves.
861g - 3. Return the surface to its original mold line.
861g - 4. So that the mounted cylinder will start cutting properly rather than running across the surface causing additional damages.
861g - 5. To determine when the drilled holes have finally reached the area of the void.
861g - 6. Enough so that there is at least 1/2 inch around the largest ply in the repair patch.
861g - 7. A dried film thickness of 0.0001 to 0.0005 inch is required. It should be continuously agitated as it is being sprayed; and if it shows signs of lumps and gelatin, do not use it.
861g - 8. At least 1/4 inch larger than the largest patch ply.

861h - 1. Whether the skin being repaired is at the top or bottom.
861h - 2. The holes are started at a 45°, then changed to 30°, once the cutting starts. The holes are drilled completely through the core material down to the back side of the opposite thin surface.
861h - 3. A filler compound.
861h - 4. The heat blanket vacuum method.
861h - 5. It must be applied slowly, have a minimum of 24 HG (12 psi), and the cured patch should be allowed to cool off to below 125° F before removing vacuum pressure.

CHAPTER 4

862 - 1. (1) They seldom break or sever even under strains.
(2) They are stronger than steel rods or tubing of the same size.
(3) Their failure is never abrupt but is progressive over periods of extended use.
(4) They flex without setting and can easily be routed around obstacles.
(5) They can be installed without a great degree of sagging.
(6) They will not work—harden as a result of vibration.

863 - 1. True.
863 - 2. False.
863 - 3. False.
863 - 4. True.
863 - 5. False.
863 - 6. True.
863 - 7. True.
863 - 8. False.

864 - 1. Nonflexible carbon steel cable.
864 - 2. Nylon coated cables.
864 - 3. Flexible carbon steel cables.
864 - 4. Nonflexible corrosion resistant steel cable.
864 - 5. Nylon coated cables.
864 - 6. Carbon steel cable.

865 - 1. Repair.
865 - 2. Replace.
865 - 3. Okay.
865 - 4. Replace.
865 - 5. Replace.
865 - 6. Okay.
865 - 7. Repair or replace.
865 - 8. Replace.

866 - 1. d
866 - 2. g
866 - 3. c
866 - 4. a
866 - 5. b
866 - 6. j
866 - 7. i
866 - 8. e
866 - 9. f
866 -10. h

867 - 1. Use diagonal or side cutters.
867 - 2. 7/32 of an inch in diameter.
867 - 3. Insert cable end approximately one-half the distance into a terminal, then bend the cable to a 45° angle, and straighten the cable back to normal and push it the remaining distance into the terminal.
867 - 4. Place terminal securely in a vise and straighten it with a mallet or with a moderate pressure from the jaws of the vise.
867 - 5. Elongation of the terminals during swaging.
867 - 6. Wrap cable with masking or friction tape and cut in the middle of the tape, so that a section of tape will remain on each end of the cut cable.

868 - 1. Install the feed guide on the swager.
868 - 2. Rotate terminal 90° before starting the second pass to remove the flash developed by the first pass.
868 - 3. Rotate rolls to the No. 1 starting position.
868 - 4. Rotate the cable and terminal 45° before making the third pass.
868 - 5. Check the equipment for:
   a. Use of improper size rolls.
   b. Damaged front plate.
   c. Damaged bearings in the swaging machine, allowing rolls to separate.
   d. Recheck operation steps for possible source of trouble.

869 - 1. Seated against the terminal and front die.
869 - 2. Light pressure is maintained on the cable toward the front of the swager.
869 - 3. They should be lightly oiled.
869 - 4. It should be placed in the bench cradle.
869 - 5. Using both hands, hold the terminal-cable assembly about 1 inch from either side of the ball-end-inserted into the cavity of front (nose) die.
869 - 6. The air must be shut off.
869 - 7. Always use the safety guard.
869 - 8. 3/4 of an inch.
869 - 9. The terminal is inserted slowly through the dies.
869 -10. Cut cable.

870 - 1. 60 percent of the minimum allowable break strength is applied for 3 minutes.
870 - 2. Hydraulic work cylinder within the swage pull tester.
870 - 3. Overloading smaller diameter cables.
870 - 4. Two soft copper blocks.
870 - 5. When the slipping occurs when testing larger diameter size cables.

CHAPTER 5

871 - 1. 1100 (½ hard) or 3003 (½ hard).
871 - 2. 2024-T or 5052-0.
871 - 3. Corrosion-resistant steel.
871 - 4. 6061-T.
871 - 5. 1100 (½ hard) or 3003 (½ hard).
871 - 6. 2024-T or 5052-0.
871 - 7. Corrosion-resistant steel.

872 - 1. c.
872 - 2. d
872 - 3. f
872 - 4. a
872 - 5. b

873 - 1. True.
873 - 2. False. Change "AN819 sleeve nut" to read AN817 sleeve nut."
873 - 3. True.
873 - 4. False. Change "block" to "natural."
873 - 5. False. Delete "natural aluminum" and insert "blue."
873 - 6. True.

874 - 1. Replace.
874 - 2. Repair.
874 - 3. Replace.
874 - 4. Replace.
874 - 5. Repair.

875 - 1. Use the damaged tubing as a template.
875 - 2. Make a template of wire at the aircraft between the connecting points.
875 - 3. Install bends in the tubing.
875 - 4. The saw blade should have at least 32 teeth per inch.
875 - 5. Apply only light pressure to the cutting wheel by intermittently twisting the thumbscrew.
875 - 6. Place the tubing in a flaring block (dies) and clamp the block in a vise.

876 - 1. By estimating the amount of metal needed to make the bend plus additional material for the flare.
876 - 2. By placing the original and replacement tubing side by side, aligning the starting points of the bends. Mark the required amount for both ends on the replacement tubing using the original tubing as a template.
876 - 3. By positioning the original tubing in the tube bender as if you were going to bend the tubing. Use the 0° mark on the radius block as a guide in marking the starting point. Each bend is marked in this way.
876 - 4. By placing both side by side, as close as possible, and marking the starting point, located earlier on the original tubing, on the replacement tubing.
876 - 5. After inserting the replacement in the tube bender, hold the original tubing close to the replacement piece, and rotate the replacement tube to match the angles on the original tubing.

877 - 1. ¾ inch in diameter.
877 - 2. By turning a handcrank that is geared to the forming die.
877 - 3. When bending thin wall tubing.
877 - 4. Move the mandrel slightly forward of the required alignment point.
877 - 5. The slide bar should be adjusted firmly against the tubing, but not with sufficient pressure to prevent the slide bar from sliding through the slide block vise jaw.
877 - 6. The clamp block should tighten firmly against the tube to prevent the tube from slipping during the bending process.
877 - 7. a. Move mandrel forward.
   b. Tighten clamp block more firmly.
   c. Use a mandrel inside the wall tubing.
   d. Move mandrel backward.

878 - 1. Both the tubing and the ladle must be kept beneath the surface of the hot water.
878 - 2. You should wait until the fusible alloy has solidified.
878 - 3. Place both the tubing and ladle in the tank of hot water and pour the fusible alloy back into the ladle.
878 - 4. The ends may be flattened or metal discs soldered in the ends.

878a - 1. The introduction of ultra-thin-wall tubing and the fact that minimum bend radii are being used.
878a - 2. The higher the working pressure (psi), the less flatness allowed; the lower the working pressure, the more flatness allowed.
878a - 3. The outside diameter of the tubing.
878a - 4. Items needed: Four factors:
   a. A pointed-type micrometer.
   b. A working knowledge of decimals.
   c. The working pressure (psi) within the tubing section.
   d. An understanding of the elements called for in the flatness formula.
878a - 5. a. Unacceptable - 12 percent.
   b. Acceptable - 4 percent.

879 - 1. True.

879 - 2. False. The flare should extend above the sleeve approximately 1/16 of an inch and be no larger than the largest outside diameter of sleeve.

879 - 3. False. A flare that is too short, should be reflared.

879 - 4. False. A flare that is too long, should be cut off and reflared.

879 - 5. True.

880 - 1. i, c, d, f, a, g, b, j, k, f, e, k, n, h, o.

881 - 1. The cone adjustment is made by matching the tubing outside diameter marks on the flaring center with the scribed index line on the spindle lead.

881 - 2. Flaring dies are slid into the channels on the vise jaws and are locked in place by turning knurled circular key into the arc slot in the flaring dies.

AU GAFS AL(842937)1, 800

STOP-

1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.

2. USE NUMBER 2 PENCIL ONLY.

53153 05 21

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
SPECIALIZED REPAIRS

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if a all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DONT'S:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed*. Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

Multiple Choice

1. (800) A thermoplastic type of plastic can best be described as a plastic that

   a. can be reheated and reformed.
   b. retains heat for long periods of time.
   c. retains its shape unless extreme heats are applied.
   d. can be heated but not reformed.

2. (800) If a type of plastic has characteristics similar to those of sulphur and sealing wax, what type of plastic is being described?

   a. Thermosetting.
   b. Thermoplastic.
   c. Chemical reaction.
   d. Cellulose nitrate.

3. (801) The specification MIL-P-5425, indicates a type of acrylic that

   a. is heat-resistant.
   b. fabricated from polyester.
   c. is a balanced laminate.
   d. resist crazing.

4. (802) If it is necessary to store different lengths of plastic sheets vertically, how should they be stored?

   a. Masking tape removed.
   b. Masking tape in place and the in bins 18 inches off the floor.
   c. Masking tape in place and arranged in order of thickness.
   d. Masking tape in place and tilted at a 10° angle in storage bins.

5. (802) If a formed plastic part is removed from storage and it is discovered that the part is deformed, what storage procedure was most probably overlooked?

   a. Surface protection.
   b. Required ground clearance.
   c. Temperature limitations.
   d. Recommended storage time.

6. (803) Which one of the following statements concerning the cleaning of transparent plastics is <u>true</u>?

   a. Cheesecloth can be used as a polishing cloth.
   b. A sponge should be used just to carry water to the plastic being cleaned.
   c. Electrostatic charges develop in plastic parts when cleaning with a damp chamois.
   d. Cleaning should be accomplished in bright sunlight when possible.

7. (804) Which one of the following identifies a delaminated window?

   a. The presence of bubbles.
   b. Visual distortion through the affected area is slight except along the edges.
   c. Visibility through the affected area is poor and badly distorted.
   d. The affected area has a rough or grained appearance.

8. (805) If crazing on a plastic part is in a random pattern, the cause can usually be directly traced to

   a. excessive cold-forming.
   b. improper installation procedures.
   c. the action of solvent vapors.
   d. excessive loading stresses.

9. (805) What type of a defect is likely to result when improper restoration (polishing) methods are used during attempts to repair scratch damages?

   a. Surface delamination.
   b. Parallel crazing.
   c. Inner ply bubbling.
   d. Visual distortion.

10. (806) What is the most likely to occur when an excessive amount of water is used to lubricate drilling holes in plastic sheets?

a. Crazing occurs.
b. Plastic becomes gummy.
c. Masking tape removal is difficult.
d. Loss of cutting heat increases weave problems.

11. (806) When drilling plastic, to avoid "grabbing" all of the following procedures should be followed except

a. fast drill speed.
b. slow rate of feed.
c. light drilling pressure.
d. moderate drill motor speed.

12. (807) Besides knowing the material composition of the plastic to be cold formed, what other factor must you know to avoid crazing the plastic?

a. Thickness of the plastic being formed.
b. The grain direction within the plastic.
c. Whether the plastic can be heated if needed.
d. Properties of the inner layer of the plastic.

13. (808) Which method of cementing is used to bond plastics using MIL-A-25055 adhesive?

a. Direct.
b. Soak.
c. Glue.
d. Cushion.

14. (808) To assure the development of adequate joint strength, what should you do prior to cementing plastic parts?

a. Heat-treat them prior.
b. Add plastic shaving to the adhesive.
c. Sand the contacting surfaces.
d. Clean contacting surfaces with methylene chloride.

15. (810) How long after bonding and cementing transparent plastic should you wait before annealing the jointed area?

a. 8 hours.
b. 16 hours.
c. 24 hours.
d. 48 hours.

16. (811) Which one of the following terms is not associated with the descriptive characteristics of laminated plastic structures?

a. Polyvinyl-butyral.
b. Balanced.
c. Unbalanced.
d. Monolithic.

17. (811) The principle behind flash-heating of laminated plastic is to

a. quickly heat the inner layer.
b. heat the outer plies before the inner ply reaches its critical temperature.
c. reduce the length of heating time by using a higher temperature.
d. decrease the crazing tendency by pin-point heating of the outer plies.

18. (812) When the proper solvent-type cement for cellulose acetate is not available, what can be used as a solvent-type cement?

a. MEK.
b. Naphtha.
c. Acetone.
d. Epoxy.

19. (813) One important factor that must be known before polishing out a scratch on an acrylic plastic assembly is

a. the direction of internal stresses within the plastic assembly.
b. the thickness of acrylic plastic assembly after polishing.
c. whether the plastic assembly can be annealed after the polishing operation.
d. whether any distortion caused by the scratch will be removed when the scratch is removed.

20. (814) When disassembling a transparent plastic assembly, what is the value of a cardboard fastener diagram of the plastic assembly?

a. The loss of fasteners is reduced.
b. Missing or broken fasteners can be easily ordered.
c. Proper replacement of each fastener is assured.
d. Torque requirements can be determined for each type and size of fastener.

21. (814) Alignment measurements are taken prior to removing and after replacing a canopy in a frame fixture to

a. check for internal stresses resulting from over-torqued fasteners.
b. assure that the frame assembly has not shifted during the replacement process.
c. permit allowable tolerances for expansion and contraction to be measured accurately.
d. determine the torque requirements for aligning the individual frame members.

22. (815) Which one of the following fiberglass assemblies consists of two or more layers of fiberglass cloth which are bonded together with the aid of heat and pressure?

a. Filament.
b. Mat molded.
c. Laminated.
d. Honeycomb.

23. (815) What type of fiberglass assembly sometimes uses glass cloth impregnated with polyester resin to construct an inner structural member?

a. Molded mat.
b. Mat molded.
c. Laminated.
d. Honeycomb.

24. (816) The type of radome that can be subjected to a certain amount of heat for anti-icing purposes is known as a

a. fluted core-type radome.
b. fowm-type radome.
c. filament-wound-type radome.
d. stratospheric-type radome.

25. (817) Minor repairs to fiberglass laminates are considered to be

a. delaminations between 2 and 3 inches in diameter.
b. surface scratches, scars, and abrasions.
c. tears which do not exceed 2 inches in diameter.
d. cracks one inch in length.

26. (818) Which one of the following statements will cause an explosion to occur?

a. Adding the catalyst to the resin without adding the promoter to the resin first.
b. Adding the promoter to the resin without adding the catalyst to the resin first.
c. Adding the promoter and catalyst together prior to adding the resin.
d. Adding the drying agent to the resin before adding the catalyst.

27. (818) Which one of the following statements is an acceptable working practice when measuring chemicals for fiberglass repairs?

a. Resins, promoters, and catalysts are usually measured by liquid ounces.
b. Resins, promoters, and catalysts are usually measured by gram weight.
c. The amount of resin, promoter, and catalyst mixed for a repair situation will depend on the temperature at the time of mixing.
d. The ratio of resin to promoter to catalyst is dependent on the amount of vacuum pressure used for the repair.

28. (819) To reduce the possibility of moisture absorption when resins are removed from cold-storage, you should

a. thin the resin by adding a small amount of MEK.
b. increase the amount of catalyst required.
c. increase the amount of promoter required.
d. bring resin to room temperature in a closed container before using.

29. (819) If a resin at room temperature appears to be gelled or substantially changed from its original viscosity, it should

a. not be used.
b. be tested prior to use.
c. be preheated prior to adding catalyst.
d. have a smaller amount of promoter added than required.

30. (820) When selecting a resin to repair laminated fiberglass assemblies, what must be known besides the method of curing before you select the correct resin?

a. Overall size of repair.
b. Number of plies being replaced.
c. Resin used by the manufacturers.
d. Curvature of the area being repaired.

31. (820) In order for a pyrometer to be useful when repairing laminated fiberglass assemblies, you must use a

a. vacuum pump.
b. thermocouple wire.
c. heat-resistant film.
d. breather strip.

32. (821) The scarf method of ply removal is preferred over the step-joint method when

a. polyester resin is being used in the repair.
b. more than two plies are being removed.
c. thin weave laminates are being removed.
d. vacuum pressure is used.

33. (821) The scarf method of removing damaged fiberglass plies differs from the step-joint as the cutout area is

a. sanded out.
b. scribed before peeling off the damaged plies.
c. determined by the number of individual plies damaged.
d. rectangular or square in shape.

34. (823) When is it necessary to sand the cured replacement plies on laminated fiberglass repairs to match the contour of the repaired area?

a. When the damaged plies are removed by using the scarf method of removal.
b. When the damaged plies are removed by using the step-joint method of removal.
c. When the cutout is made on the inside surface of a curved structure.
d. When vacuum pressure and heat are applied during the curing of the replaced plies.

35. (824) What should be done to help in the removal of the duxseal barrier used during a fiberglass repair?

a. Add oil to the duxseal before forming the barrier.
b. Place the duxseal barrier over the PVA film.
c. Lightly coat the surface around the repair area with wax.
d. Lightly sand the area around the repair with a fine grit sandpaper.

36. (824) If the curing temperature for a fiberglass repairs is 400° F., the vacuum material film needed would be

a. polyvinyl fluoride film.
b. polyvinyl alcohol (PVA) film.
c. polyvinyl chloride film.
d. cellophane mylar film.

37. (825) If you were making a minor repair to a laminated fiberglass panel, which one of the following would normally be the third work procedure you yould use?

a. Sand off excessive resin.
b. Clean damaged area thoroughly with MEK.
c. Lightly sand the damaged area using #280 grit sandpaper.
d. Mix resin according to the applicable technical order.

38. (826) Which one of the following statements is in agreement with acceptable guidelines used for inspecting fiberglass repairs?

a. Holes that penetrate only the outer ply are permitted.
b. Wrinkles are permitted on the inside surface of the repaired area.
c. Blisters of 1/4 of an inch in diameter are permitted on the inner plies of fiberglass repair.
d. Weave pattern and direction should not be visible through the resin.

39. (827) What is the most important precaution that should be taken when transporting any radome from the shop to the aircraft?

a. A protective coating should be applied to the surface.
b. Transport radome to the aircraft on a maintenance stand.
c. Cover surface of radome with paper or a similar material.
d. Transport radome to the aircraft on a padded dolly.

40. (827) When a radome must be stored, you should do all of the following except

a. place the radome in a suitable crate or padded rack.
b. apply a protective coating to the surface of the radome.
c. store the radome out of the weather.
d. cover the surface of radome with paper or a similar material.

41. (828) What type of resin used in the construction of honeycomb radomes is grouped in specification MIL-R-7575C?

a. Polyesters.
b. Epoxies.
c. Air cured.
d. Heat cured.

42. (829) When evaluating a damaged radome, which one of the following guidelines is used to determine whether a radome is repaired or replaced?

a. Number of previous repairs.
b. Repair cost versus replacement cost.
c. Elongation of edge band mounting holes.
d. Past electrical history of the radome.

43. (829) Which one of the following statements is not applicable when making radome repairs?

a. Electrical testing is required before and after all repairs.
b. Repairs should restore original electrical and strength properties.
c. Round or oval shaped patches should be used when possible.
d. Uniformity in thickness or core, facings, and cell size are important factors that must be restored.

44. (830) Why is it necessary to know the direction of the threads in the original facings when replacing surface facings on honeycomb radomes?

a. The facing cutout has to be made perpendicular to the direction of the threads.
b. The facing cutout has to be made parallel to the direction of the threads.
c. Replacement facings must match the original direction of the threads.
d. Replacement facings must be layed cross-wise to the original thread direction.

45. (830) If it is necessary to form a section of honeycomb replacement core to fit a sharp curvature, what work procedure is recommended?

a. Cut the replacement core into smaller pieces.
b. Place stress relief notches on the top edge of the replacement core.
c. Cut the inside surface of the replacement core to match the curvature of the repair area.
d. Use a contour mold and apply heat and vacuum pressure to the replacement core.

46. (831) Which one of the following statements concerning resins that is used in the repair of a honeycomb radome is true?

a. Resins can be made to cure at different temperatures by adjusting the amount and type of promoter.
b. Polymerization of the resin is affected by ambient temperatures and humidity.
c. Resin mix formulation will only change by increasing or decreasing the heat applied for curing.
d. Honeycomb radomes will be repaired using only Class 1 or Class 2 polyester resin mixture.

47. (832) When fabricating a pressure blanket, which one of the following work procedures is not required?

a. The PVC film should be at least 0.020 thick.
b. The shape of the pressure blanket should be cut to conform to the repair area.
c. The size of the pressure blanket should be large enough to clamp to a suitable stretching bar.
d. Tension spring attachment holes should be located along the outer edges of the pressure blanket.

48. (833) When is it recommended that a radome be electrically tested prior to starting a repair?

a. When radome has extensive field repairs.
b. When radome has been damaged by lightning.
c. When errosion resistant coating is delaminated.
d. When the damage is located in the "window" area of the radome.

49. (835) In order to prevent the joints of the inner and outer repair areas of a Class III radome repair from being directly opposite each other, you should

a. use the scarf cutout method of damage removal on one side and the step-joint cutout method on the other side.
b. place one additional ply of fiberglass cloth on the inner surface.
c. complete the repairs on one side of the radome before starting the opposite side repair.
d. make the first cutout ply for the inner repair larger than the first cutout ply on the outer repair.

50. (836) When a radome is inspected for moisture and oil contamination by using an ID-712 moisture detector, the proper testing procedures involve

a. holding the moisture detector 6 inches from the radome with zero adjustment knob in the right-hand position.
b. taking readings within 6 inches of all field repairs.
c. testing the entire radome surface to within 3 inches of any metal edge members.
d. heating the surface of the radome to 100° F. prior to placing the moisture detector on the radome.

51. (837) Which one of the following work practices correctly states the acceptable technique of repairing predrilled attachment holes in the laminated edge band of honeycomb radome?

a. Laminated core plugs are bonded inside the holes.
b. A paste consisting of microballons is used to fill the holes.
c. A Class II laminated fiberglass repair is performed.
d. A putty-like mixture consisting of resin and chopped fiberglass strands is used.

52. (838) Metal bonded honeycomb construction consists of

a. two layers of similar metals separated by a piece of glass cloth laminate.
b. a core bonded between two layers of glass cloth laminates.
c. a core bonded between two metal facings.
d. metals that must be heat-treated prior to use on an aircraft.

53. (838) The rigidity and strength of metal bonded honeycomb are the result of the

a. honeycomb core material being stood on end.
b. facings being machined to close tolerances.
c. structural binder added to the adhesive.
d. various surface configuration developed in panel assemblies.

54. (839) The existance of water in a metal bonded honeycomb panel is normally considered to be a

a. Class I damage.
b. Class II damage.
c. Class III damage.
d. Class IV damage.

55. (840) In order to satisfactorily perform a tapping test on a metal bonded honeycomb panel, you should

a. place the panel assembly on a padded surface.
b. apply a vacuum of at least 10 PSI to the panel.
c. be familiar with the internal construction of the panel.
d. remove any excessive resin within the panel before testing.

56. (840) A caustic soda solution is used on metal bonded honeycomb panels to

a. check the results of cleaning operations.
b. prepare a damaged area for proper adhesive adhesion.
c. indicate surface facings delaminations.
d. check surface defects for clad penetration.

57. (841) Which one of the following working practices relating to the tools used to repair metal bonded honeycomb panels is correct?

a. Before an explosive meter can be used, it must be checked for broken grounding wires.
b. When starting a cutout using a router, it should be checked at 45° from the work surface.
c. When a router is used for making a cutout, it is moved in a counter-clockwise direction during the cutting operation.
d. Double-backed tape is used on a router template whenever there is the possibility of causing galvanic corrosion.

58. (841) When applying vacuum pressure, a correct work precedure is to

a. assure that all core cells are filled with adhesive.
b. apply a surface primer to the area to aid in preventing the pressure jig from moving.
c. install a 6-inch long wedge block on the pressure jig before using.
d. apply glycerin to the surface area to obtain a good vacuum.

59. (842) When using a core slicer assembly to make angular cuts on honeycomb replacement core material, the

a. fixture assembly must have double-back tape on the bottom surface of the base to prevent movement.
b. horizontal arm must be adjusted to angle of cut required.
c. door pull handles are used to guide the fixture assembly during the cutting.
d. hinged table must be parallel to the flat base.

60. (842) The configuration of the core plug produced when using a cylindrical core cutter is directly related to the

a. length of the core replacement material.
b. type of material used in the outer facing.
c. amount of pressure used to cut the core material.
d. positioning of the cutter over the core material.

61. (843) If heat and a parting agent is required to repair a metal bonded honeycomb panel, you would be using

a. infrared heating lamps.
b. an electrically operated heat gun.
c. an air-circulating oven.
d. thermostatically-controlled heating blankets.

62. (844) Repairs using glass cloth components and adhesives usually have a maximum curing temperature of

a. 180° F.
b. 200° F.
c. 240° F.
d. 350° F.

63. (845) If the ideal working or pot life temperature for a paste adhesive used for metal bonded honeycomb repairs is 70° F., which one of the following temperatures would the work or pot life be reduced in half?

a. 52° F.
b. 88° F.
c. 130° F.
d. 140° F.

64. (846) When repairing metal bonded honeycomb panels, Epon 933

a. is used with microballons and curing agent "T."
b. requires the use of a surface conditioner Epon 927.
c. can be thinned using MEK solvent.
d. has a work life of 12 hours when stored in an open container.

65. (847) The glass cloth adhesive mixture of Versamids and Epons will do all of the following except

a. cure at 130° F. in one hour.
b. cure at a room temperature of 70°.
c. remain workable for 12 hours at room temperature.
d. bond two 6-inch diameter layers of glass cloth for each 20 grams batch mix.

66. (848) When replacing a core plug, what determines the size foam-in-place tape adhesive that you will select?

a. Curing temperature used.
b. Cell size of the core material.
c. Amount of vacuum pressure to be used.
d. Type of material being used as a replacement core.

67. (849) If it takes three layers of glass cloth No. 181 when repairing a surface facing of .012, how many layers of glass cloth No. 128 would be required?

a. The same amount of layers.
b. One less layer.
c. One more layer.
d. Two more layers.

68. (850) Which of the following correctly states a repair principle associated with making metal bonded honeycomb repairs?

a. Hot bonded repairs are superior to cold bonded repairs.
b. Cold bonded repairs are equal to hot bonded repairs.
c. Glass cloth patches are equal to metal overlay patches.
d. Metal patches lack the surface adhesion that glass cloth patches have.

69. (851) When cleaning the surface of an aluminum honeycomb panel for repair purposes, surface greases and oil are removed by

a. abrading the surface with aluminum wool.
b. using a solution of mild soap and distilled water.
c. scrubbing the repair area with trichlorethylene cleaner.
d. placing the panel in an air-circulating oven and heating at 180° F. for 30 minutes.

70. (851) What is indicated when a film of distilled water fails to break when the water is used to test the surface of a metal bonded honeycomb panel?

a. The distilled water is contaminated with foreign matter.
b. A cleaning solvent is still present on the surface.
c. The test was conducted above room temperature.
d. The surface needs no further cleaning.

71. (852) Before a surface fitting putty can be applied to a dent in a metal bonded honeycomb panel, the following conditions must be met except the surface must be

a. slightly dampened with water.
b. sanded to a uniformly dull condition.
c. cleaned of all paint traces.
d. chemically cleaned using MEK and lacquer thinner.

1000

72. (852) While using a surface filling putty to repair dents in a metal bonded honeycomb panel, air entrapment and soft spots can best be minimized by

a. mixing components on a clean hard surface.
b. vacuum curing the repair area.
c. intermixing components of one manufacturer with those of another.
d. assuring that the proper ratio of components are mixed together.

73. (853) After the dent puller assembly is set-up to remove a dent from a metal bonded honeycomb panel, which procedure causes the dented skin to be pulled upward?

a. Rotating the mandrel clockwise.
b. Turning the retaining nut counterclockwise.
c. Rotating the mandrel counterclockwise, while holding the retaining nut stationary.
d. Turning the retaining nut clockwise, while not holding the mandrel stationary.

74. (854) When drilling holes in a delaminated area of a metal honeycomb panel for injecting adhesive, you should

a. pilot-drill all holes to avoid drilling into cell walls.
b. step-drill all holes to assure proper adhesive injection.
c. drill deep enough into the core material to permit the adhesive flow during injection to remove any moisture present.
d. drill holes first at the top and bottom of the delaminated area.

75. (855) The principle behind checking a metal bonded honeycomb panel for moisture by using the weighing method of detection involves

a. weighing a panel before and after repairs are made.
b. comparing the weight of a panel before and after heat and vacuum pressure has been applied.
c. following the calculation method of balancing guidelines.
d. removing the end seals and weighing the water removed.

76. (857) When replacing a damaged portion of honeycomb core with aluminum core material, which one of the following is a correct work procedure?

a. Use core material with a larger cell size.
b. For trail edge repairs, the cell wall should be normal to the repaired skin.
c. The thickness of the core material should equal the original core thickness when making non-flush repairs.
d. The replacement core should be the same size as the cutout cavity.

77. (857) When installing a glass fabric core plug in a cutout area on a metal bonded honeycomb panel, a correct work procedure would be to

a. include thicknesses of old bondlines when determining the thickness.
b. "butter" the replacement plug after insertion to assure a proper bonding surface.
c. clean the plug with distilled water and air-dry for at least 15 minutes.
d. apply EC-776R sealer to all fraying surfaces of the plug.

78. (858) If incorrect, how can the following statement be made correct: A core separator is required when all of a damaged glass fabric or aluminum core material is not removed?

a. The statement is correct as it stands--no changes are needed.
b. The word "not" should be deleted from the statement.
c. "When repairing both facings" should be added to the end of the statement.
d. The words "or aluminum" should be deleted from the statement.

79. (858) When making a metal bonding honeycomb repair involving the use of metal repair parts, which of the following is the best procedure to use?

a. The width of skin patches should be twice its length whenever possible.
b. Determine the amount of overlay required for non-flush patches by using the original skin thickness.
c. Cut core separators to match only undamaged core cells.
d. To assure good adhesive adhesion, coat metal parts with a thin layer of MEK.

80. (859) If after removing damage to both facings and core in a metal bonded honeycomb panel an additional amount of inner facing and core material is removed, you would be making a metal

a. flush repair.
b. non-flush repair.
c. combination flush and non-flush repair.
d. repair after removing water from a transition area.

81. (860) Under which of the following conditions is it necessary to use wedge blocks when making metal bonded honeycomb repairs?

a. Anytime a repair is to be hot bonded.
b. When routing out aluminum core materials.
c. Repairs accomplished in the bay area of a panel.
d. Repairs are accomplished in the transition area of a panel.

82. (860) When is it permissible to cut a replacement core shorter than required for a honeycomb panel repair?

a. When smaller size core cells are used in the replacement core.
b. Whenever metal patches are to be used as overlays.
c. To allow adhesive buildup during trailing edge repairs.
d. When microballoon patting compound is used to bond the core in place.

83. (861) Which one of the following is <u>not</u> a factor to consider when removing and replacing a metal bonded honeycomb panel?

a. Whether or not the aircraft must be jacked.
b. Condition of the new panel when it is received from supply.
c. Cleaning of repair location within shop area.
d. Type of core material needed for core replacement.

84. (862) Which one of the following is the best reason that cables are used in aircraft to operate control surfaces?

a. Failure is never abrupt and sudden.
b. Defects are easily detected.
c. One person can fabricate replacement assemblies.
d. They can be adjusted to increase or decrease tension loads.

85. (864) Which of the following statements related to aircraft cables is true?

a. Preforming reduces the bending and twisting stresses in the strands of cable.
b. The distance parallel to the axis of the strand in which the strand makes one complete turn about the axis is known as cable diameter.
c. An independent wire rope center (IWRC) for a 7 x 7 cable consists of a six wired strand.
d. To keep cables from spreading when cut, cables are constructed with a reverse lay.

86. (864) A cable that has been fabricated by the electric furnace process, coated with pure zinc, and is constructed in 1 x 7 or 1 x 19 designs is classified as what type of cable?

a. Nylon coated cable.
b. Nonflexible cable.
c. Flexible cable.
d. Flight control cable.

87. (865) A cable that has had a kinked area straightened

a. can be left in service.
b. must be repaired or replaced.
c. requires testing for broken wires within the kinked area.
d. should be coated with lubrication over the kinked area.

88. (866) To change cable directions within an aircraft, you would use a

a. turnbuckle assembly.
b. cable drum housing.
c. pulley assembly.
d. bellcrank unit.

89. (867) To reduce the strain placed on the strands of a cable during swaging, you would

a. remove one wire from each strand.
b. lubricate the cable end before insertion into terminal.
c. bend cable after partial insertion into terminal to a 45° angle.
d. reduce the number of strokes accomplished during the swaging operation.

90. (868) After the rolls on a Kearney swager have been mounted and tightened in place, what is the next step in setting up the machine for swaging straight-shank terminals?

a. Insert cable and terminal in place.
b. Position proper feed guide adapter in place.
c. Rotate terminal 90° after inserting into rolls.
d. Rotate rolls to the No. 1 starting position.

91. (869) Before operating the pneumatic swager after inserting the terminal, where should the rear die be positioned?

a. In the rear of the bore opening.
b. Approximately 1 inch from the front die.
c. Seated against the terminal.
d. In the No. 1 starting position.

92. (870) When testing a fabricated cable to pass the test, how long must the cable maintain a test load of 60 percent of the minimum allowable breaking strength?

a. Until cable slips slightly from jaw guides.
b. For a minimum time of 30 seconds.
c. Until signs of external kinking occurs.
d. For a maximum time of 3 minutes.

93. (871) When repairing external brake lines which have been broken on an aircraft, you would use

a. 2024T aluminum alloy tubing.
b. 5052O aluminum alloy tubing.
c. 6061T aluminum alloy tubing.
d. corrosion-resistant steel tubing.

94. (872) If you are unable to read the lettering on a piece of tubing, but you can make out the gray color of the lettering, you would know that the tubing is

a. 1100 aluminum alloy.
b. 2014 aluminum alloy.
c. 5052 aluminum alloy.
d. 6061 aluminum alloy.

95. (873) Which of the following statements correctly identifies a factor related to the types of tubing fittings?

a. The AN817 sleeve is used in conjunction with the AN818 coupling nut.
b. The AN fittings incorporates a swage-type sleeve.
c. The installation of MS fittings requires a flaring operation.
d. The sizes of tubing fittings correspond to the outside diameter of the tubing.

96. (874) Under which one of the following conditions would it be necessary to remove and replace tubing?

a. A dent which is located on a straight section of tube is equal in depth to 20 percent of the tubing diameter.
b. A nick has been burnished out on the heel of a bend.
c. A depth of a nicked area on steel tubing is equal to 10 percent of the tubing's wall thickness.
d. A nick is located on a bend in a piece of tubing that is required to carry 75 psi.

97. (874) Tubing which has a dented area must be removed and replaced if the dent is

a. equal to 15 percent of the diameter of the tubing.
b. located within 6 inches of a fitting.
c. in tubing that operates under 100 psi.
d. located on a heel portion of a bend.

98. (875) The use of a tube cutter is the recommended method of cutting tubing except when

a. cutting steel tubing.
b. installing MS-type fittings.
c. cutting the tubing has a wall thickness of above 0.063.
d. preparing tubing for presetting operations.

99. (875) When tubing is being replaced and the old tubing is used as a template, how would you locate the start of a second bend on replacement tubing if you were using a hand tube bender?

a. Measure the old tubing from the starting point of the first bend to the ending point of the second bend and transfer the measurement to the replacement tubing.
b. Mark starting point of the second bend on the old tubing, then transfer this mark to the replacement tubing, after aligning the first bend.
c. Perform a few practice bends on a scrap piece of tubing until the correct allowance is obtained, and then bend the replacement piece.
d. Make a wire template of the old tubing and use the template to determine the starting point of the second bend.

100. (878) To reduce the changes of a fusible alloy from sticking inside the tubing, you should

a. heat the tubing using a torch or flame after making the bend.
b. pour the alloy back into the ladle while the tubing is cool.
c. lightly coat the inside walls of tubing with oil prior to inserting the fusible alloy.
d. place the tubing and ladle in hot water when removing the fusible alloy.

101. (878) When using a filler matter, such as sand or shot as an aid in bending tubing, the most important factor to consider is to

a. seal the ends properly.
b. make the bend in small steps.
c. lubricate the inside walls of the tubing to prevent scarring of the walls.
d. heat the tubing during the bend process.

102. (879) Why is the following statement incorrect: Incomplete flares can be drawn down properly by increasing the torque?

a. Incomplete flares will interfere with the matching of the fitting threads, preventing proper draw down.
b. Incomplete flares will cause the sleeves to climb up on the flares and prevent proper gripping force of the fitting.
c. Incomplete flares are likely to seat against the bottom of the male fitting, preventing an increase in torque.
d. Incomplete flares are used only in tubing connections requiring low torque requirements.

103. (881) If the spindle on the powered single flaring machine has been adjusted for one size tubing, what must you do to readjust it for another size tubing?

a. Change the dies to match the outside diameter of the new size tubing.
b. Change the flaring center setting to match the outside diameter of the new size tubing.
c. Change the tube stop finder adjustment based on the wall thickness of the new size tubing.
d. Replace the cone inside the spindle to match the outside diameter of the new size tubing.

104. (881) When is it necessary to reduce the speed of the spindle to a medium setting on a powered single flaring machine?

a. When flaring thin wall aluminum tubing.
b. When flaring heavy wall steel tubing.
c. When flaring stainless steel tubing.
d. When flaring normal thickness steel tubing.

105. (882) When setting up the squaring and burring head on the powered single flaring machine, how many blades are adjusted prior to cutting?

a. 1.
b. 2.
c. 3.
d. 4.

106. (884) When beading tubing, which one of the following is a correct work procedure to use?

a. Select rollers to match the wall thickness of the tubing.
b. Use a beading machine for tube diameters up to 1 15/16 of an inch.
c. Tighten the beading screw down after each rotation.
d. Lubricate the inside and outside surfaces of the tubing.

107. (885) When presetting sleeve for MS fittings, the amount of torque required is indicated by the

a. number of rotations of the nut.
b. degree of longitudinal movement of the sleeve.
c. distance the sleeve is placed from the end of the tubing.
d. material composition of the sleeve.

108. (886) When repairing a tube with Permoswage fittings, insertion marking tool is used to

a. position the swaging to head assembly.
b. locate the correct place to cut the tubing prior to the preswaging process.
c. indicate the proper distance from the end of the tubing for placement of the fitting.
d. indicate gaps between the swaged fitting and the tubing.

109. (887) Which type of balancing condition involves maintaining a control surface balanced while in motion?

a. Static.
b. Dynamic.
c. Overbalancing.
d. Underbalancing.

110. (888) The combination of force (weight) and distance is represented in balancing terms as

a. moment (M).
b. weight (WS).
c. symbol C.
d. symhol B.

111. (889) If you add 10 pounds, 20 inches to the rear of the hinge centerline of a control surface, how much weight must you add to a balance bay area 15 inches forward of the hinge centerline?

a. 10 lbs.
b. 13.3 lbs.
c. 18.6 lbs.
d. 20 lbs.

112. (889) Under which of the following conditions would it be necessary to add an additional 15 lbs of weight to a balance bay area 20 inches forward of a hinge centerline on a control surface?

a. When a repair accomplished 20 inches to the rear of the hinge centerline adds 10 lbs to the control surface.
b. When a repair accomplished 15 inches to the rear of the hinge centerline adds 5 lbs to the control surface.
c. When a repair accomplished 10 inches to the rear of the hinge centerline adds 10 lbs to the control surface.
d. When a repair accomplished 30 inches to the rear of the hinge centerline adds 10 lbs to the control surface.

113. (890) The method of wheel balancing that can be accomplished in the shop without the use of a scale is the

a. trial weight method.
b. calculator method.
c. component method.
d. moment method.

114. (891) A group of light rays is termed

a. light waves.
b. a beam of light.
c. a ray of light.
d. a directional light.

115. (892) When a beam of light strikes a highly polished piece of metal held at a 45° from the perpendicular, the light is

a. refracted.
b. reflected in a regular pattern.
c. reflected in an irregular pattern.
d. refracted converging to a specific point.

116. (893) Which of the following is a true statement related to optical prisms?

a. Prisms are used to form optical axis of a telescope.
b. Light rays entering a prism within the critical angle are reflected.
c. Light rays entering a prism beyond the critical angle are refracted.
d. Prisms are used to shift the position of the light rays.

117. (894) The internal part of a telescope which compares to a motion picture screen upon which an image is projected is called the

a. focusing lens.
b. eyepiece lens unit.
c. crosshair reticle (ring).
d. objective lens.

118. (894) The mechanical axis of a telescope is defined as

a. an imaginary straight line which passes through the center of the telescope barrel.
b. the point at which a telescope rotates about its horizontal axis.
c. an imaginary straight line which passes through the center of the lenses of the telescope.
d. the point at which a telescope rotates about its vertical axis.

119. (895) Which one of the following statements indicates the correct definition for the optical term "parallax"?

a. Occurs only when the telescope is at its infinite focus.
b. Movement of the crosshair across the image in a telescope when the eye is moved.
c. The capacity of a telescope lens to show detail.
d. Movement of the image across the crosshairs of a telescope when the eye is not moved.

120. (896) Which one of the following functions can be accomplished by using a sight level?

a. Establish intersecting points on vertical and horizontal planes.
b. Rotate about its horizontal axis.
c. Establish a horizontal plane.
d. Maintain an accuracy of $\pm$ 0.010 of an inch at 60 feet.

121. (897) To lock the azimuth scale to any desired reading on a transit, you would use the

a. upper horizontal clamping screws.
b. horizontal tangent screws.
c. lower horizontal clamping screws.
d. vertical clamping screws.

122. (898) To compensate for variations in distance between the tilting dumpy level and various targets, you would

a. turn the tangent screw clockwise.
b. adjust the eyepiece focusing ring.
c. turn the tilting screw until the proper focus is obtained.
d. adjust the objective focusing knob.

123. (899) When performing an alignment check with auto-reflection equipment, to obtain a zero-zero reading, you would

a. position the mirror half way between the aircraft and the telescope.
b. adjust the mirror so that it is on a path perpendicular to the telescope.
c. adjust the telescope to position the image on the 0.010 of an inch dash marks on the target.
d. place the target so that it is parallel to the line of sight.

124. (899) In order to perform an alignment check using auto-reflection equipment, the target must be

a. positioned half-way between the aircraft and mirror.
b. located on the base of a transit so it can be rotated.
c. highly polished and inspected to insure proper regular reflection valves.
d. attached to the telescope so that distance can be measured.

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ATC/ECI SURVEY

The remaining questions (125-135) are not part of the Volume Review Exercise (VRE). These questions are a voluntary ATC/ECI survey. Using a number 2 pencil, indicate what you consider to be the appropriate response to each survey question on your answer sheet (ECI Form 35), beginning with answer number 125. Do not respond to questions that do not apply to you. Your cooperation in completing this survey is greatly appreciated by ATC and ECI. (AUSCN 100)

PRIVACY ACT STATEMENT

A. Authority: 5 U.S.C. 301, Departmental Regulations

B. Principal Purpose: To gather preliminary data evaluating the ATC/ECI Career Development Course (CDC) Program.

C. Routine Uses: Determine the requirement for comprehensive evaluations in support of CDC program improvement.

D. Whether Disclosure is Mandatory or Voluntary: Participation in this survey is entirely voluntary.

E. Effect on the Individual of not Providing Information: No adverse action will be taken against any individual who elects not to participate in any or all parts of this survey.

QUESTIONS:

125. If you have contacted ECI for any reason during your enrollment, how would you describe the service provided to you?

a. Excellent.
b. Satisfactory.
c. Unsatisfactory.
d. Did not contact ECI.

126. My ECI course materials were received within a reasonable period of time.

a. Strongly agree.
b. Agree.
c. Disagree.
d. Strongly disagree.

127. The condition of the course materials I received from ECI was:

a. A complete set of well-packaged materials.
b. An incomplete set of well-packaged materials.
c. A complete set of poorly packaged materials.
d. An incomplete set of poorly packaged materials.

128. The reading level of the material in the course was too difficult for me.

a. Strongly agree.
b. Agree.
c. Disagree.
d. Strongly disagree.

129. The technical material in the course was too difficult for me at my present level of training.

a. Strongly agree.
b. Agree.
c. Disagree.
d. Strongly disagree.

130. The illustrations in the course helped clarify the information for me.

a. Strongly agree.
b. Agree.
c. Disagree.
d. Strongly disagree.

131. Approximately how much information in the course provides general information about your AFSC?

a. Between 80 and 99%.
b. Between 60 and 79%.
c. Between 40 and 59%.
d. Between 20 and 39%.

132. Approximately how much information in this course was current?

a. Between 80 and 99%.
b. Between 60 and 79%.
c. Between 40 and 59%.
d. Between 20 and 39%.

133. The format of the text (objective followed by narrative and exercises) helped me study.

a. Strongly agree.
b. Agree.
c. Disagree.
d. Strongly disagree.

134. The volume review exercise(s) helped me review information in the course.

a. Strongly agree.
b. Agree.
c. Disagree.
d. Strongly disagree.

135. Check the rating which most nearly describes the usefulness of the information in this CDC in your upgrade training program.

a. Excellent.
b. Satisfactory.
c. Marginal.
d. Unsatisfactory.

NOTE: If you know this CDC contains outdated information or does not provide the knowledge that the current specialty training standard requires you to have for upgrade training, contact your OJT advisor and fill out an AF Form 1284, Training Quality Report.

STUDENT REQUEST FOR ASSISTANCE

PRIVACY ACT STATEMENT

AUTHORITY: 44 USC 3101. PRINCIPAL PURPOSE(S): To provide student assistance as requested by individual students. ROUTINE USES: This form is shipped with every ECI course package. It is utilized by the student, as needed, to place an inquiry with ECI. DISCLOSURE: Voluntary. The information requested on this form is needed for expeditious handling of the student's need. Failure to provide all information would result in slower action or inability to provide assistance.

SECTION I: CORRECTED OR LATEST ENROLLMENT DATA: MAIL TO: ECI, GUNTER AFS, ALA 36118

1. THIS REQUEST CONCERNS COURSE

2. TODAY'S DATE

3. ENROLLMENT DATE

4. PREVIOUS SERIAL NUMBER

5. SOCIAL SECURITY NUMBER

6. GRADE/RANK

7. INITIALS

LAST NAME

8. OTHER ECI COURSES NOW ENROLLED IN

9. ADDRESS: (OJT ENROLLEES - ADDRESS OF UNIT TRAINING OFFICE/ALL OTHERS - CURRENT MAILING ADDRESS)

ZIP CODE

10. NAME OF BASE OR INSTALLATION IF NOT SHOWN ABOVE:

11. AUTOVON NUMBER

12. TEST CONTROL OFFICE ZIP CODE/SHRED

SECTION II: Old or INCORRECT ENROLLMENT DATA

1. NAME:

2. GRADE/RANK:

3. SSAN:

4. ADDRESS:

5. TEST OFFICE ZIP/SHRED:

SECTION III: REQUEST FOR MATERIALS, RECORDS, OR SERVICE

(Place an "X" through number in box to left of service requested)

ADDITIONAL FORMS 17 available from trainers, OJT and Education Offices, and ECI. The latest course workbooks have a Form 17 printed on the last page.

1	EXTEND COURSE COMPLETION DATE. (Justify in Remarks)
2	SEND VRE ANSWER SHEETS FOR VOL(s): 1 2 3 4 5 6 7 8 9 - ORIGINALS WERE: NOT RECEIVED, LOST, MISUSED
3	SEND COURSE MATERIALS (Specify in remarks) - ORIGINALS WERE: NOT RECEIVED, LOST, DAMAGED.
4	COURSE EXAM NOT YET RECEIVED. FINAL VRE SUBMITTED FOR GRADING ON (Date):
5	RESULTS FOR VRE VOL(s): 1 2 3 4 5 6 7 8 9 NOT YET RECEIVED. ANSWER SHEET(s) SUBMITTED ON (Date):
6	RESULTS FOR CE NOT YET RECEIVED. ANSWER SHEET SUBMITTED TO ECI ON (Date):
7	PREVIOUS INQUIRY (ECI FORM 17, LTR, MSG) SENT TO ECI ON:
8	GIVE INSTRUCTIONAL ASSISTANCE AS REQUESTED ON REVERSE:
9	OTHER (Explain fully in remarks)

REMARKS: (Continue on Reverse)

OJT STUDENTS must have their OJT Administrator certify this request.	I certify that the information on this form is accurate and that this request cannot be answered at this station. (Signature)
ALL OTHER STUDENTS may certify their own requests.	

ECI FORM JUN 77 17 PREVIOUS EDITIONS MAY BE USED

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SECTION IV: REQUEST FOR INSTRUCTOR ASSISTANCE

NOTE: Questions or comments relating to the accuracy or currency of textual material should be forwarded directly to preparing agency. Name of agency can be found at the bottom of the inside cover of each text. All other inquiries concerning the course should be forwarded to ECI.

VRE ITEM QUESTIONED:

Course No. _____

Volume No. _____

VRE Form No. _____

VRE Item No. _____

Answer You Chose (Letter) _____

Has VRE Answer Sheet been submitted for grading?

☐ YES ☐ NO

REFERENCE
(Textual support for the answer I chose can be found as shown below)

In Volume No: _____

On Page No: _____

In_____ (Left)_____(Right) Column

Lines_____Through_____

MY QUESTION IS:

Remarks: